THE DENTAL PRACTITIONER
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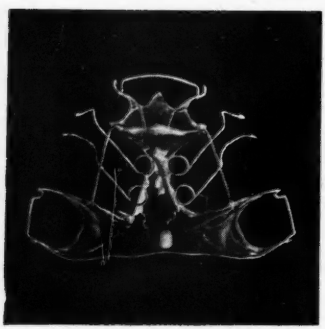

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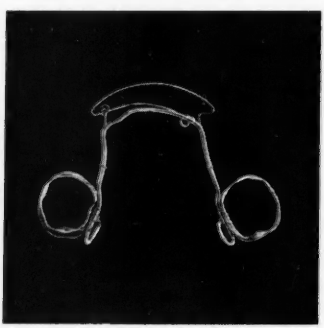

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THE DENTAL PRACTITIONER
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Vol. XI, No. 11 July, 1961

EDITORIAL

TO-MORROW'S CONSULTANTS?

In the early days of the National Health Service the number of registrar grade appointments in hospitals was increased considerably. Many candidates came forward to compete for these posts at that time, but more recently fewer numbers have been applying. This is especially so in the case of dental registrars. It has also become apparent that the standard of potential ability among those seeking these appointments is much less. This must in time reflect upon the general standard of hospital service to the public and is surely a factor which should be looked into and steps taken to improve the position.

What would appear to be the cause?

Firstly, the number of practitioners required at junior levels in the hospital service far exceeds the number of consultants; the inevitable pyramid. This naturally results in a small proportion of those commencing a career in hospital dentistry achieving consultant status; which, of course, is comparable with what happens in any other vocational activity—but in this day and age security seems to mean more than ambition.

Secondly, the salaries of junior hospital staffs do not compare favourably with those earned by their contemporaries in general practice. Even with the salary of a consultant, say of the age of 38, with to-day's high rate of income tax, it is not a complete recompense for the poor pay rates for the first 15 years of professional life. This is especially important to the young practitioner who, during this period, has some of his heaviest financial burdens, in making a home and educating a family.

What can be done to improve the situation? It has been customary for these junior posts to be a form of post-graduate training which registrars undertake largely on their own initiative. Those who have energy and drive gain much, while the less energetic obtain little or nothing. It may be said in this respect that here the natural law of selection is at work. However, there should be a more positive approach to the instruction of junior staffs. There should be a definite stage-by-stage programme for those who would retain these appointments. To-day, not all those who take registrar appointments seek higher qualifications. Unless there is a definite object in view, reading is spasmodic and study fragmentary. One must also recognize that the cost of courses, examination fees, and faculty subscriptions is high for relatively impecunious men.

Nevertheless it should be remembered that a period of service in junior and middle grade registrar posts combined with the study

[*continued on page* 389]

SIBILANT SOUNDS OF SPEECH*

By **PETER STREVENS**, B.A.
Lecturer, School of Applied Linguistics, University of Edinburgh†

A GREAT many branches of scientific study concern themselves with various regions of the respiratory tract and its associated auditory and other mechanisms. Most of these subjects, and dentistry is one of them, deal with the care and maintenance of all or part of the respiratory tract as an anatomical and physiological structure; they are interested in the continued operation of its primary functions of respiration and deglutition. But these same regions of the human body have secondary, or overlaid, functions by which man is able to exercise his unique faculty of communication by language. The nature of language itself, and the patterns and structure of particular languages, are the province of the science of linguistics. Within linguistics, but overlapping into other fields, is the science of phonetics, which studies the sounds of human speech, their production, their organization into systems and patterns, their classification and description, their acoustic nature, and so on.

Clearly, part of the study of phonetics touches the same anatomical regions that are the specialized province of the dentist, and the purpose of this paper is to describe a recent investigation into language events produced largely in the mouth; that is, into sibilant sounds, the manner in which they are produced, and their acoustic nature. But there is another reason for describing this particular piece of work: it is that the investigation embraces several different branches of experimental phonetics and thus offers a bird's-eye view of much of the new, scientific study of speech.

One preliminary difficulty that faces any speaker who wishes to communicate his own subject to specialists from another field is that they may have preconceptions about the speaker's subject. This is frequently true of laymen's views on phonetics. "*Everyone* knows about phonetics. It means using letters upside-down in order to learn to speak French." This was the kind of folk-legend that was widely held until the recent popularity of *My Fair Lady* led to another legend, that of phonetics as a system of teaching people to "speak posh". Such myths bear no relation to modern phonetics. Phonetics is not letters upside down; nor is it a revised spelling; nor yet a kind of elocution. Phonetics is, quite simply, the name given to the scientific study of human speech. The subject has an ethos of its own; it also has some highly developed techniques of classification and description. But in this paper we are concerned only with the corpus of factual knowledge which has been built up within the discipline of phonetics, and with a single attempt to increase our detailed understanding of certain kinds of speech-sound, namely, those sounds to which the traditional term "sibilants" is sometimes applied.

The whole programme of investigation arose in an unusual way which merits a few words of explanation. The Phonetics Department of Edinburgh University operates an artificial talking machine, under a Government research contract. This machine was designed by a communications research engineer, Mr. Walter Lawrence; a replica was constructed in Edinburgh by Mr. James Anthony. The machine is commonly known as "PAT", from the initials of its descriptive label, "Parametric Artificial Talker". It is essentially an electrical analogue, or model, of the human vocal apparatus. If appropriate instructions are given to the machine, it produces sounds which approximate quite closely to human speech.

The ability to programme this machine pre-supposes the possession of adequate information about the nature of the sounds we are trying to make. The machine has no innate language ability; it is simply a sound generator. It can only make complex and varying noises according to a programme; the

* Paper read before the Odonto-chirurgical Society of Scotland, Feb. 11, 1960.

† Now Professor of Contemporary English, University of Leeds.

programme necessarily consists of acoustic data. In the early stages of work with the machine it was difficult to distinguish between shortcomings due to deficiencies of design on the one hand, and deficiencies of programming on the other. But it gradually became clear that although the acoustic nature of vowels, diphthongs, and certain other sounds could be described with considerable accuracy, we were quite unable to describe a whole range of essential speech-sounds. These sounds included, in particular, the class popularly known as "sibilants", which had been very little studied. It was inherent in the conception of the machine and of our work with it that "PAT" was theoretically capable of producing utterances in every dialect of every language in the world. Indeed, "PAT" has now been programmed to produce phrases in English, Swedish, Polish, and Karen (a language of Burma), and it is about to be given a programme for utterances in Gaelic. But, in 1957, it was clearly a major requirement that acoustic specifications of the sibilants should be made, otherwise a great many essential contrasts and distinctions were beyond "PAT's" capabilities.

Let us put the problem into practical terms. With a certain amount of *ad hoc* manipulation of the controls, "PAT" could be made to produce a hissing sound approximately like [s]. This was adequate for words like *say* or *sigh*; but for words like *shy* even our best attempts were not very satisfactory. In any case, although "PAT" could produce a given sibilant as many times during one utterance as might be required, it was quite unable to change, in the course of an utterance, from one sibilant to another. Thus "PAT" was at least theoretically capable of making a reasonable attempt at a phrase like "Swiss rolls are super", or even "She shot the shepherd"; but the famous tongue-twister "She sells sea-shells on the sea-shore" was beyond the capabilities of the machine for this reason alone, that it entailed a programmed alternation between these two sounds, [s] and [ʃ]. As for sounds like those at the beginning of the words *thing*, *four*, or *huge*, they could not be produced with any acceptable degree of naturalness.

It became clear that we had to investigate these sounds before we could state what modifications must be made to the machine to overcome this serious deficiency.

Two questions immediately presented themselves: What sounds were to be investigated? And by what means? The first question can be re-stated in this way: should we confine our study to those hissing sounds which occur most commonly in English, or should we look at all possible types of such sounds, in all languages? It is typical of the outlook on linguistic phonetics that has been developed at Edinburgh under the guidance of Mr. David Abercrombie that we should have selected the general approach, rather than confining ourselves to items from a particular language. It is true that in any case the total number of sibilants in all known dialects of English is surprisingly large. But we decided that we must select our items according to general phonetic principles, because, if we did this, then the description of the items of *any* language, whether it was English or Javanese, would automatically be covered. The name of the general category of sounds to be studied is "voiceless fricatives". (The term "sibilant" is not a technical term in current usage in phonetics, but it translates very closely into the precise label, "voiceless fricative".) Having decided on the nature of the material to be studied, thirteen of my colleagues and research students each recorded a set of nine voiceless fricatives, as isolated items.

The choice of a method of analysis was not difficult. The science of phonetics has been revolutionized within the past fifteen years by data obtained with the *sound spectrograph*. The University of Edinburgh Phonetics Department acquired in 1951 the first sound spectrograph to be operated in Europe, and has used it for teaching and research ever since. Once a small pilot scheme had shown that useful results could be obtained by this method, a large programme of spectrographic analysis was undertaken. To understand what this means, we can ask the question, What does a sound spectrograph do? The answer is that it gives a visual picture of sounds. It displays the spectrum of the sound being studied, in the

form of a graph, with frequency on the vertical axis and time on the horizontal axis. *Fig.* 1 illustrates the kind of pictures that are produced. These pictures are patterns of energy, distributed at various frequencies and at different moments of time. The figure is a representation of the word "spectrogram".

inserted at one end of the rotating barrel, and as they are shaken down to the farther end, so pieces of increasing size are able to drop through the appropriate holes. In the sound spectrograph the sample to be analysed is first recorded; this recording is then re-played many times over, and put through an acoustic

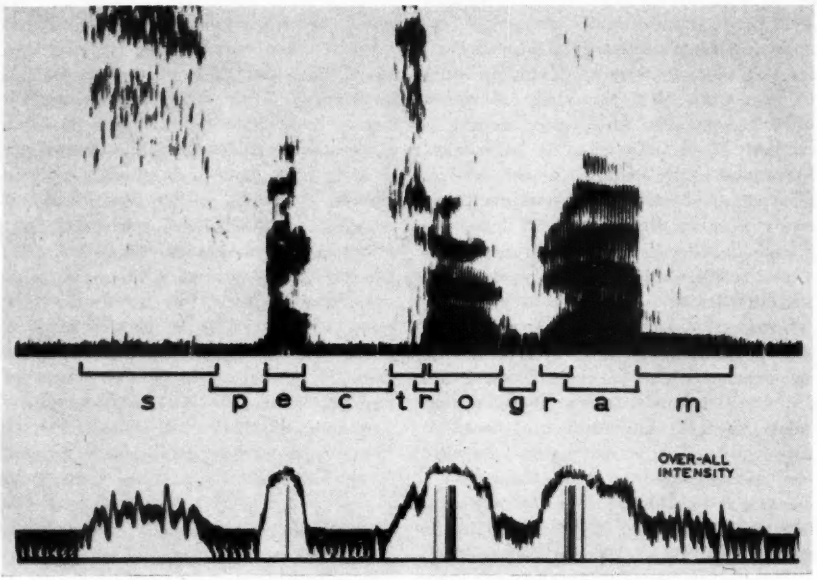

Fig. 1.—Visible speech patterns of the word "spectrogram". *Above*, a normal display; *below*, a display of acoustic intensity.

The most important feature of this illustration, from the point of view of the investigation we are discussing, is the difference that can be clearly seen between the vowels, which show large bands of energy, and the voiceless fricatives, which show energy at all frequencies down to a certain limit. These features will be seen again later.

It is a simple job to describe, by analogy, the way the sound spectrograph works. Most people have seen at some time one of the grading machines with which quarries and gravel-pits sort pieces of rock into different sizes. The procedure consists of rotating a long inclined barrel, with holes in it. The holes become bigger in size at progressive points along the barrel. The pieces of rock are

filter whose frequency is increased at each successive playing. Thus the instrument asks the question, Is there any energy present at 50 cycles per second? At 75 c.p.s.? At 100 c.p.s.? At 125 c.p.s.? And so on. A drum on which is placed a sheet of special paper rotates in exact synchronism with the playing of the recording. As it rotates, the drum passes a stylus, which moves steadily up the paper in synchronism with the sweep of the filter. Consequently, the disposition of the marks on the paper is related in a fairly simple manner to the distribution of energy at various frequencies and at various moments of time within the recorded sample.

The core of the present investigation was to take the recorded fricatives and to make from

them several hundred spectrograms, whose patterns were confronted, compared, contrasted, and measured. It was found that significant variations could be detected between classes of sounds. But, before looking at these patterns, we shall consider briefly the manner in which hissing sounds are produced.

So much for common knowledge. It seemed desirable to try to find out more precisely what factors were operating in the production of fricative noise, and why noise produced in different places sounded so different.

At the time when this problem arose, a colleague, Dr. Peter Ladefoged, was engaged

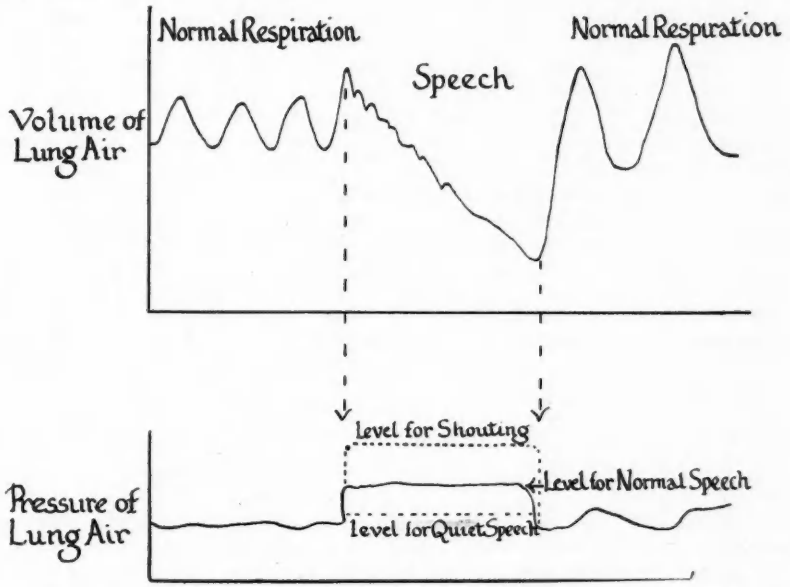

Fig. 2.—Relation between volume and pressure of lung air. (*After Whitteridge, Draper, and Ladefoged.*)

Let us begin with the facts that are common knowledge. Everyone knows that speech-sounds are the result of interfering in some way with a stream of air passing outwards through the respiratory tract. If the breath-stream passes through the larynx with the vocal cords fully open, in the position for breathing, then the characteristic sound of *voice* is not heard, and any speech sounds that may be produced are termed *voiceless*. If the breath-stream is forced to pass through a narrow constriction, the air-flow becomes turbulent, and a hissing noise is produced; this is called *fricative noise*, or audible friction. The fricative noises produced by constriction at various points in the tract are, of course, distinguishable from one another.

in physiological experiments. In conjunction with Professor Whitteridge and Dr. Draper, he was investigating the musculature of respiration. In particular, the group were interested in the relations between the "firing" of various sets of muscles, and the pressure and flow of air into and out of the lungs. Their interest extended to a comparison of the data for respiration and for speech, and even to the study of the differences which accompany different levels of loudness of speech. From this constellation of experiments three main facts stood out as being relevant to the work on fricatives. After a brief description of the experiments it will be easy to appreciate what these facts were.

The physiological experiments used techniques of electromyography. This means that electrodes were inserted into various sets of muscles. The electrodes consisted of ordinary hypodermic needles with a fine, insulated wire down the centre of them; the electrical measurements took place at the tip of the needle, between the central wire and the body of the needle. When the muscles came into operation, the accompanying electrical potentials were picked up by the electrodes and taken to an oscilloscope, where they were photographed.

The pressure of the air in the lungs was measured by a small, air-filled bulb in the end of a tube. The bulb and tube are passed up the nose and down to the œsophagus. Since this is separated from the trachea at this point by only a thin membrane, the pressure on the bulb in the œsophagus is virtually the same as the pressure in the lungs. The flow of air was measured by putting the subject into a large barrel, with an air-tight seal round his neck; the barrel had a single outlet for the air surrounding his body, leading to a recording spirometer. A microphone was hung before his face, and the whole proceedings were recorded on magnetic tape.

Obviously the more of these readings that could be taken at the same moment, the easier it would be to observe the interaction of the various factors. Accordingly an experimental climax was arranged in which Dr. Draper was subjected to several simultaneous needle electrodes, a nasal catheter, and emplacement within the barrel. Simultaneous records of all the data were thus made possible for the first time.

Fig. 2 shows the kind of results obtained from this series of experiments.

Considering these results in relation to everyday experience of speech, and especially of fricatives, three important facts emerged which were relevant to the work on hiss sounds. The first was that for a given level of loudness of speech the air-pressure remained constant within fairly close limits. The second was that a greater level of general loudness was always accompanied by higher air-pressure. The third was that while higher air-pressure led to greater loudness of *all* sounds uttered, including fricatives, at the same time the differences of *relative* loudness between different fricatives continued to exist.

From these facts, certain inferences were plain. First, the differences between fricatives in any given utterance were probably not due to the small, rapid variations of air-pressure, since such variations were very slight. Secondly, major variations of air-pressure were related *only* to variations of loudness, since increases in pressure were accompanied by increases of loudness, but were not accompanied by changes of quality. Thirdly, there were inherent differences of loudness between different fricatives, for example, between [ʃ] and [θ], since even at the highest general levels of loudness there seemed to be differences as between different fricatives.

This last inference could be checked by a fairly simple set of experiments. If we were to speak each of our selection of test fricatives, in isolation, many times, with varying degrees of loudness from a whisper to a shout, it should be possible to measure the acoustic energy by means of a microphone and voltmeter, while measuring the air-pressure at the same time, by means of the nasal catheter technique.

Dr. Ladefoged and I tried this experiment in a rough and preliminary way and found that there does indeed seem to be an inherent difference of loudness between some fricatives and others. This difference can be thought of as an indication of relative efficiency as a hiss-making mechanism. To put it another way, greater loudness for a given air-pressure is clearly more efficient, as a system for the conversion of kinetic energy into acoustic energy, than is a lower level of loudness for the same air-pressure. As a result of these tests I have tentatively grouped these fricatives into three sets, having intensity at a low, medium, or high level, respectively. The interesting fact about this grouping is that it corresponds to the place of articulation within the vocal tract. Those fricatives made interdentally or anterior to the teeth tended to show the lowest inherent energy per unit air-pressure; those made in the region between the posterior surface of the teeth and the

beginning of the velum tended to have the greatest inherent energy; those made on the velum or farther down the tract towards the larynx tended to have a level of inherent energy intermediate between the two extreme ranges.

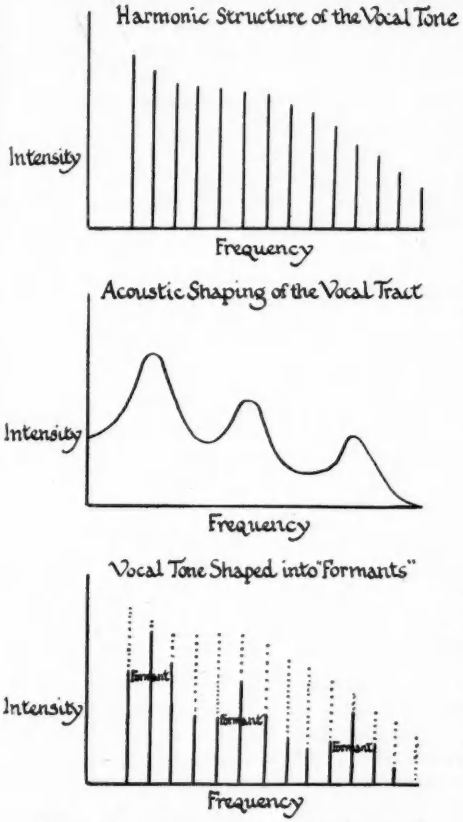

Fig. 3.—The vocal tract, its acoustic analogue, and the "shaping" effect which the tract exerts upon sounds transmitted through it. (*After Miller.*)

We now had some knowledge of the effects of variations of air-pressure, and had learned that these variations did not appear to cause any alteration in the quality of the sound, but only in its loudness. Sound quality must therefore be related to one of two further factors: either the *nature* of the constriction in the vocal tract, or else the *place* of the constriction, or both.

The next problem was thus to try to discover what kinds of constrictions are made when turbulent air-flow occurs. Unfortunately we know a great deal more about the behaviour of air-streams at speeds approaching that of sound than we do about the acoustic behaviour of air at the relatively slow speeds attained by the breath-stream in speech. Nevertheless, the gross facts are clear: there is a very wide range of shapes and sizes of orifice, which constrict the air-stream at a large number of points (or areas) between the larynx and the lips. Part of the corpus of knowledge of traditional, physiological phonetics has been a catalogue of these various orifices. Those which occur between the teeth, or anterior to them, tend to be associated with a wide, narrow slit, and probably also with the effect of air passing

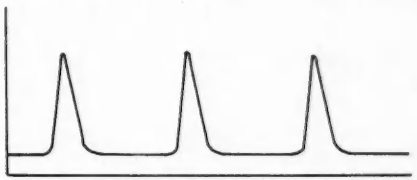

Fig. 4.—An approximation to the wave-form of the human vocal tone, at the glottis.

through the interstices between the teeth. Those fricatives made behind the teeth, as far back as the end of the hard palate, tend to be associated with a deformation in the surface of the tongue, either a groove, or a pit, or a rill; and, of course, the upper surface of the air-channel in these cases is hard, and therefore probably less sound-absorbent than in other cases. The details of the fricatives made farther back in the mouth are known with less certainty, but, in any case, no hard surface is involved, while the source of the sound is close to one of the major cavities of the vocal tract, namely, the pharynx.

These anatomical details can be checked to some extent by the technique of palatography (which is, of course, well known to the dental profession) and especially by the techniques of direct photopalatography as developed at Edinburgh by Mr. James Anthony, A.M.I.E.E.

Measurements in three dimensions can be made by the addition of an elegant refinement

devised by an American phonetician, Dr. Stanley Sapon. He uses a fine-wire grid of known dimensions, which the technicians of the Edinburgh School of Dental Surgery kindly constructed. This grid appears superimposed on the photograph of the palate, but it also casts shadows on the palate. Simple trigonometry then provides exact details of the surface configuration of the palate.

There remained one main question: What is the difference in the sound quality of sounds made by orifices of different shapes? We still do not know the precise answer, but it seems likely that the differences are in fact very small. (When the air-stream passes between the teeth, or over flat surfaces with sharp angles, there may be a small contribution from whistles and from "edge-tone" effects. But these contributions seem to be only slight in comparison with the total acoustic energy.)

In general, the physical nature of the sound quality of voiceless fricatives can be roughly described as "noise"; that is, sound in which all frequencies are present at equal intensity but with random distribution. In other words, there is no regularly recurring wave-shape such as is produced by a "musical" sound, for instance a tuning-fork. A convenient generic term for the sound common to voiceless fricatives is "hiss". Sounds which are partly fricative and partly voiced can then be described as having a component of hiss.

A crucial point had now been reached in the argument. Each of the voiceless fricatives has a different sound quality from the others. This is not due to differences of air-pressure, since these had been shown to relate only to loudness. In the absence of any clear evidence to the contrary it could be assumed that all hiss is roughly similar in sound quality regardless of the orifice which produced it. Only one factor remained, that of position within the vocal tract. Differences of sound quality might be due to the effect exerted by the tract itself on the hiss, being different, at different places.

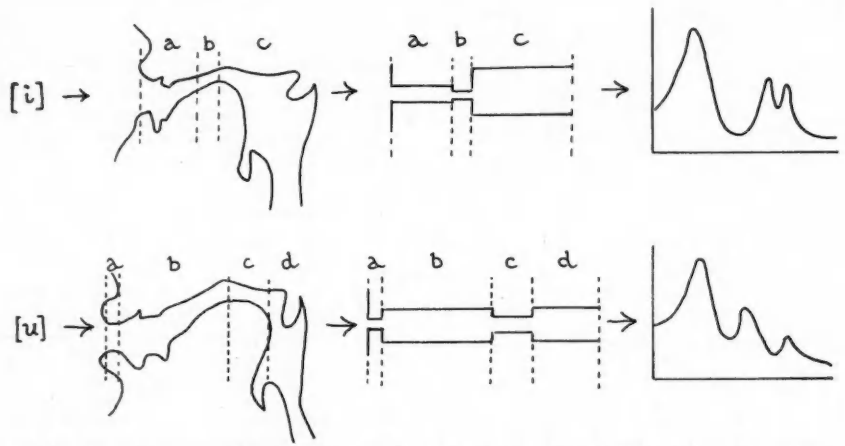

Fig. 5.—Acoustic spectrum of the vocal tone at the glottis, showing how this is shaped by the vocal tract. (*After Miller.*)

One of the results of research in acoustic phonetics has been that speech can now be described as a physical event, and not, as in the past, solely as a physiological or anatomical event. It is known that the vocal tract consists of a series of air-spaces, or cavities, coupled together end-to-end. These cavities are in fact resonance chambers, which can be set into resonance by any suitable impulse.

Fig. 3 is a diagrammatic representation of the vocal tract, its analogue (or equivalent) in terms of acoustics, and the "shaping effect"

that this will have on any sound transmitted through the cavities.

The commonest form of impulse that sets the air in the cavities into vibration is, of course, voice. The glottis opens and closes a large number of times each second during phonation, between roughly 80 and 200 times, depending on the age and sex of the individual, and the linguistic and social context. The wave-form of the glottis is probably something like that in *Fig.* 4. A wave-form shaped like a spike or saw-tooth is not a single frequency or pure tone like the sound of a tuning-fork. It contains a great many components, but the intensity of each one decreases as its frequency increases.

Fig. 5 is a diagram representing this, and showing the effect which the resonances of the vocal tract have upon the sound. On the *left* diagram is a representation of the glottal spectrum, that is, the distribution of the energy along the frequency scale. The *middle* diagram represents the shaping effect of the cavities, while the *right* diagram shows the spectrum of the sound as it is actually heard. To put the matter in simple terms, if one set up a battery of tuning-forks, each somewhat higher in frequency than the previous one, and if each were struck with the same energy, some of the frequencies would be transmitted through the vocal tract quite well, but others would be considerably damped down.

Three main points must be made. First, different cavities will give different shaping. This is one reason why male and female voices are different: the size and shape of their vocal tracts differ. Adult and child voices differ for similar reasons, and so do different individuals within each of these categories. Secondly, the articulatory movements of speech cause almost continual changes in the size and shape and even the number of cavities in the tract. The tongue, especially, moves within the mouth and thereby alters its resonances and consequently its acoustic shaping from one articulation to the next. Thirdly, the effect of acoustic shaping will be applied to any sound introduced into the vocal tract. The implications of resonance theory have been readily accepted in describing vowels, and by implication even in belching when this is used as a voice-substitute; but they have been somewhat neglected as they apply to the vocal tract when this is excited by hiss instead of voice.

But there is an important difference between voice and hiss: voice is always produced in the same place, at the larynx; hiss, on the other hand, may be produced at any of a large number of different points between the larynx and the lips. One way in which the acoustic shaping will be likely to reflect the place of origin of the hiss is by the degree to which it resembles vowel shaping, according to the proximity of the place of origin of the hiss to the larynx. When the spectrograms of hiss were examined, this was roughly what could be observed.

The presentation of the data which emerge from the comparison of several hundred spectrograms is a difficult matter. *Fig.* 6 shows a pair of spectrograms which were used in the project. In this case the sound was [s] as in "sin". The question arises whether this sample is typical of all the patterns for [s]. In *Fig.* 7, portions of each of the spectrograms of [s] from each of the 13 subjects have been set alongside each other. Individual variations can be seen, but a generic pattern is also visible.

The next obvious question is whether the other voiceless fricatives also display generic patterns, and if so, how these can be distinguished from each other. The answer is that they do, but that the differences are complex and therefore not always obvious. In *Fig.* 8 a sample of each of the different spectrograms from a single subject have been put beside each other. It is possible to see fairly large differences between some sets of patterns, but this form of display is still not sufficiently simple for the principles to be clearly seen. An improvement is to reduce each spectrogram to a single line drawn on a frequency scale; the only details shown are the lower and upper frequency limits, and a cross-bar wherever some kind of peak of energy appeared. This procedure enables us to draw up diagrams such as *Fig.* 9, in which the data for every speaker of a given item can be seen at a glance.

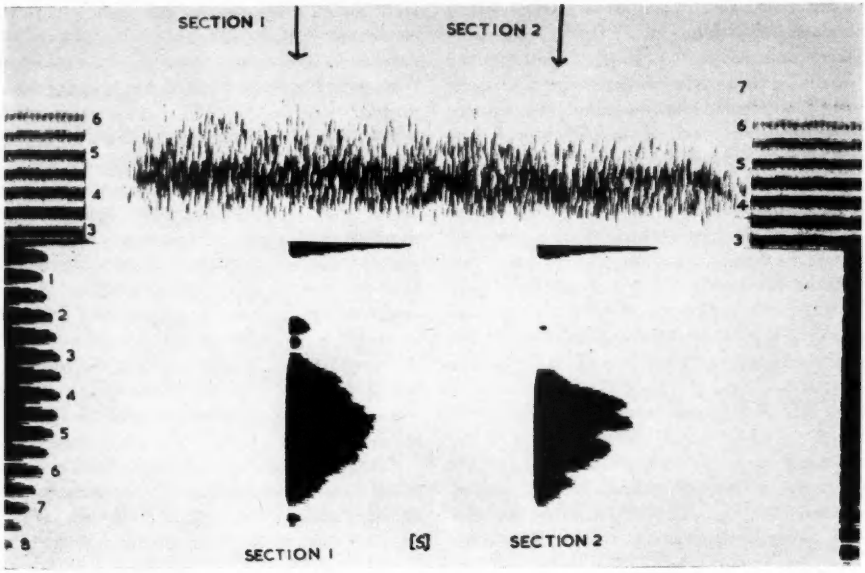

Fig. 6.—Spectrograms and cross-sections used to investigate fricative spectra. Frequencies in kilocycles.

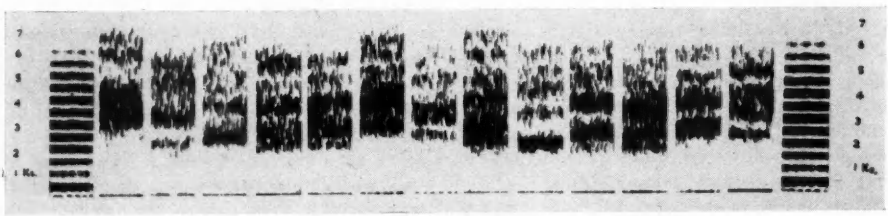

Fig. 7.—A composite from all spectrograms of [ʃ] (as in "ship").

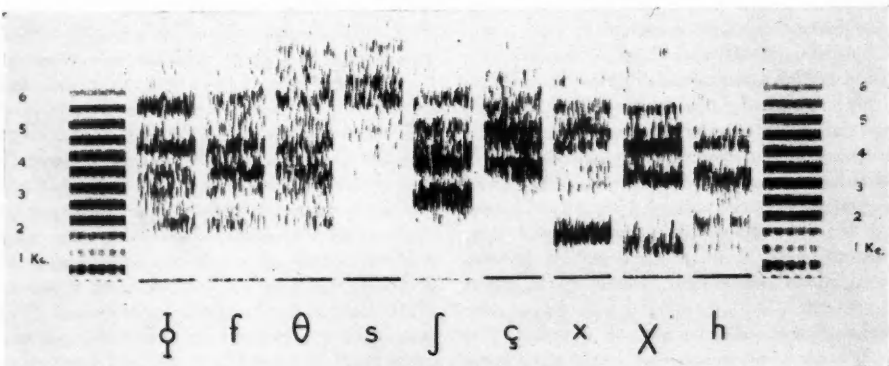

Fig. 8.—A composite from all fricatives of one speaker.

The last stage in the process is to take an average line spectrum from each set and to put them side by side. This allows us to see fricatives fall into three categories. The Front group (that is, the first three counting from the left) have the lowest degree of inherent

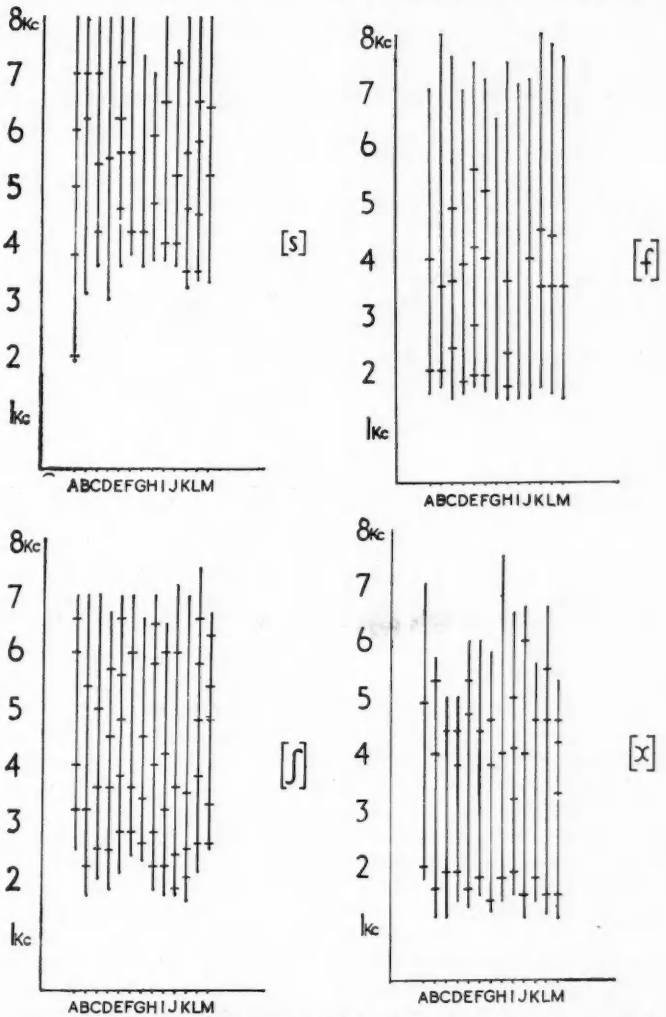

Fig. 9.—Line spectra for all occurrences of [s], [f], [ʃ], [x] (as in "loch"). (*By courtesy of the Editor of "Language and Speech".*)

the gross similarities and differences quite easily, and has been done in *Fig.* 10.

If, at this point, the conclusions about inherent intensity are recalled, then the intensity, a bottom limit of frequency about 1800 c.p.s., and an upper limit around 7000 c.p.s. This group includes English [f] as in "fin" and [θ] as in "thin". It will be

seen that the differences are small and mostly appear at high frequencies. This would account for the ease with which these sounds are confused in telephone speech, where the frequencies above about 3500 c.p.s. are not

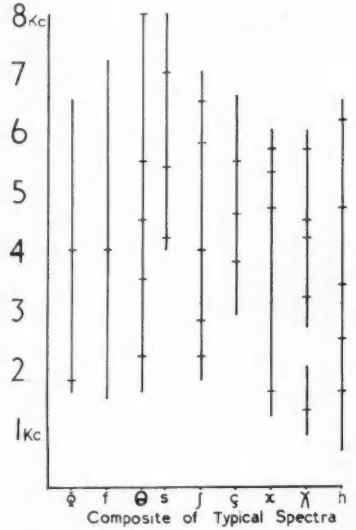

Fig. 10.—Composite diagram of all line spectra. (*By courtesy of the Editor of "Language and Speech".*)

transmitted at all. These sounds are all produced inter-dentally or anterior to the teeth.

The Mid group, which include English [s] as in "sin" and [ʃ] as in "shin", all have the highest level of inherent intensity, which makes it fairly easy to distinguish them, as a class, from the preceding group, except that in telephone speech most of the energy of [s] is lost. These two English sounds are fairly easily distinguished from each other by their bottom limits of frequency, which are around 2000 c.p.s. for [ʃ], but almost double that for [s]. These sounds are all produced on the alveolus or the hard palate.

The last three, the Back fricatives, are the sounds whose inherent intensity was at the intermediate level. The lower limits of frequency are much lower than for any of the other sounds, and become progressively lower as the place of articulation approaches the larynx. Each of these sounds has a peak of energy around 1500 c.p.s., which is roughly the same as the lowest formant in vowels. These sounds are all produced farther back than the hard palate.

The task is now complete, at least as far as the broad outlines are concerned. Statements can now be made in physical terms about the acoustic nature of the voiceless fricatives. In order to be able to do this it has been necessary to use data from a wide range of different sources and methods: data about the place and manner of articulation, from palatography, and from X-ray films; about pressure and intensity, from spirometry, electro-myography, and œsophageal pressure recording; about the acoustic spectrum, from spectrography and wave-form analysis. All these techniques, and very many others which were not relevant to this particular programme of investigation, are continuously in use at Edinburgh, enlarging our understanding of the nature of human speech.

The Use of Corticoids in Pulpal Healing

Ninety patients with pulpitic symptoms of varying intensity were treated with application of triacinolon (fluoro-hydroxy-prednisolone), a synthetic corticoid. This was applied as a paste after radical removal of all carious material.

In the first series of 26 patients, 6 failures occurred.

In a second series, 64 patients were treated. A dressing of triacinolon-chloramphenicol xylocaine was left in the cavity for 7 days. This was replaced by a zinc-oxide and oil of cloves dressing containing 30 per cent by weight of triacinolon-chloramphenicol for another 7 days. The permanent restoration was then inserted. Success was obtained in all cases although many pulps were exposed by excavation. Patients suffering pain were included. Symptoms disappeared within two years. All cases were checked for their ultimate vitality.—SCHROEDER, TRIDAN J. (1960), *Schweiz. Mschr. Zahnheilk.*, **70**, 724.

M. PLEET

EXTRA-ORAL FIXATION AND HÆMOSTATIC ACRYLIC SPLINTS FOR PATIENTS SUFFERING FROM DISEASES OF BLOOD-COAGULATION

By **D. S. HAYTON-WILLIAMS**, M.A., M.R.C.S., L.R.C.P., L.D.S.
Consultant Oral and Maxillofacial Surgeon, Churchill Hospital and Radcliffe Infirmary, Oxford

PATIENTS suffering from a bleeding diathesis frequently present a major problem with respect to the control of hæmorrhage following dental extractions. As a result of 71 consecutive operations on patients with hæmophilia and Christmas disease, and 23 consecutive operations with von Willebrand vascular defect disease, a successful plan of control has been established. This has been accomplished by the use of splints and a controlling head-gear which is described below. The disability may be divided into one of two groups, although at times they are combined:—

1. Disorders of clotting mechanism, e.g., hæmophilia and Christmas disease.

2. Structural and/or functional defects of blood-vessels, e.g., von Willebrand's disease, Ehlers-Danlos syndrome.

In both cases intra-oral splints may be used. In the first group, pressure is contra-indicated. Their purpose is to prevent disturbance of blood-clot by tongue, cheek, fingers, food, or drink.

In the second group, pressure is an advantage until blood has clotted firmly, but the splint also has a protective purpose as in the previous case.

Good splints are essential. Poor splints would probably do more harm than good. Margins of safety are so narrow that it is attention to detail that makes for success.

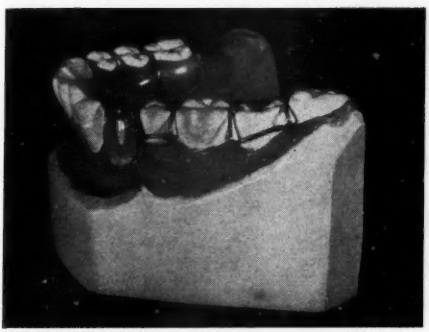

Fig. 1.—Splint to be fitted after removal of $\overline{|4}$.

Fig. 2.—Numerous cribs to ensure stability of splint.

The procedures which will be described have been developed gradually in this Department over some ten years with C. Wishart, now of Salisbury, and R. A. J. Mayhew, now of King's College Hospital, London. We have all worked in the closest co-operation with our hæmatologists, Dr. R. G. Macfarlane and Dr. Rosemary Biggs of the Medical Research Council Blood Coagulation Unit in the Churchill Hospital.

Good impressions, in an elastic material, of teeth and alveoli of both jaws are necessary. The models must be located accurately in an articulator.

DESIGN

1. Splints where some Natural Teeth will be Preserved.—The teeth that are to be removed are trimmed from the plaster model. The

model is surveyed, undercuts blocked out, and then duplicated.

The splint outline is arranged so that all tooth sockets are not just barely covered, but considerably overlapped to prevent any disturbance of blood-clot (*Fig.* 1). Standing teeth are cribbed in order to obtain the maximum stability and rigidity of the splint made of clear methyl methacrylate (*Fig.* 2). For this purpose Adams orthodontic cribs and their modifications have proved extremely satisfactory. It is essential that attention to detail is paid in fabrication so that no adjustments will prove necessary in the operating theatre, except possibly to tighten the cribs. The splint, when in position, must be stable in all directions; any movement would tend to cause the blood-clot to disintegrate rather than to consolidate and organize.

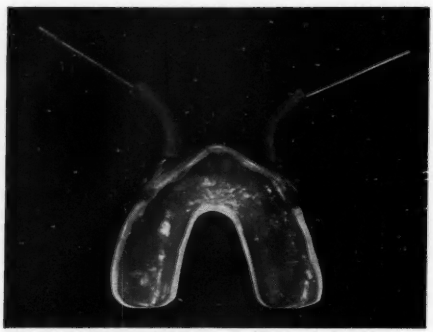

Fig. 3.—Full upper splint with extension arms.

When the bleeding defect is vascular, some slight raising of the bite might be advantageous, but *not* in a clotting defect.

2. Splints for the Upper Jaw when all Upper Teeth will be Removed.—We have found it better to remove all upper teeth prior to the lower teeth in the event of it being necessary to render a patient edentulous.

The only method we have evolved so far to make a full upper splint stable is to attach it to a plaster-of-Paris headcap. This permits free post-operative opening of the mouth for feeding and inspection and, if necessary, the removal of the splint for cleaning and reinsertion. The headcap is not always tolerated by hæmophiliacs, the precise reason being difficult to elucidate, as it has never produced demonstrable soreness. The brass arms are readily detachable from the splint, so facilitating processing and any adjustments. They are connected to the home-made "goal-posts" on the headcap by two lateral rods which are fixed by universal joints, such as are used in maxillofacial traumatic surgery (*Figs.* 3, 4).

Fig. 4.—Plaster-of-Paris headcap with extra-oral attachments.

3. Splints to the Lower Jaw when all Teeth will be Removed.—When the upper sockets have healed it is necessary to take a new impression of the upper jaw. The upper and lower jaw relationship is recorded, and the models articulated. The lower model will need the teeth cut off. Upper and lower plates are made with well-rolled margins, and maximum coverage of alveolus. Space must be left between them in the mid-line, so as to permit ingestion of food and fluid while jaws are immobile. Brass arms are attached to the lower splint (*Fig.* 5).

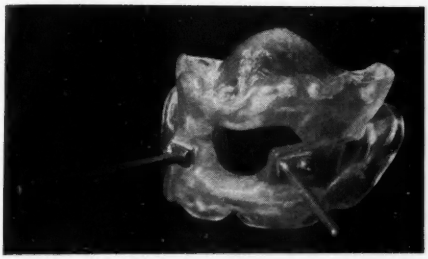

Fig. 5.—Upper and lower splints for fitting after removal of lower teeth.

Fig. 7.—Splints, chin cap, and barrel bandage applied.

An alginate impression is taken of the chin with ample coverage of the submandibular region. An acrylic chin cap is made with a single central rod which, following the operation, will be joined to the lower splint by universal joints and bars (*Fig.* 6). We have found the single rod, rather than two rods, more popular with patients, as it allows them some turning of the head on the pillow. The chin cap should be kept well clear of the lips as food tends to drop behind the edge. Stability of the splints is reinforced by a barrel bandage (*Fig.* 7).

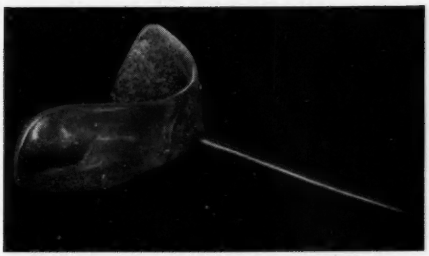

Fig. 6.—Acrylic chin cap with central rod.

We line all splints at operation with a little Calgitex wool on to which is syringed, or poured, Russell viper venom ("Stypven").

SUMMARY

This paper describes a method of splinting which we have found satisfactory. No features of diagnosis, nor any other aspects of treatment, are considered. This plan has been adopted following nearly 100 successful operations.

It would, however, be a relief to patients, and to clinicians, if splints and headcaps could be dispensed with.

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THE PERIODONTIUM IN ORAL SURGERY*

By **A. D. HITCHIN**, D.D.Sc., M.D.S., F.D.S. R.C.S.
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THE surgery of the periodontium is by no means a new subject. It is the oldest branch of dentistry, for the removal of aching teeth has been the approach to such problems from primitive times. Indeed, tooth extraction is essentially disruptive periodontal surgery. It is not, however, my intention to discuss in this paper such radical procedures, except in so far as conservative considerations may be brought to bear on the periodontium of neighbouring teeth, when perforce one must be removed.

Just as it is the objective of the periodontologist to maintain the surrounding tissues of the teeth in a condition of as near health as possible and to encourage its attainment, so also the modern oral surgeon must not only respect these tissues, but also study the surgery of them, particularly from the point of view of their maintenance in health in spite of his operative procedures in their proximity. There is, in fact, no demarcation line between the field of the periodontologist and that of the oral surgeon; and therefore discussions regarding the no-man's-land between these specialities may be both fruitful and not without interest.

If it was possible for a tooth to be well educated, it might well regard the whole patient as its periodontium; but our viewpoint for present purposes must be somewhat more restricted, and we must confine ourselves essentially to those tissues which immediately surround the teeth—in short, their attachment. It is convenient to divide our considerations into two parts. First, conditions and operations affecting the periodontium of teeth which have already erupted, and secondly, the conservative surgery of unerupted teeth, bearing in mind that the objective usually is to encourage the development and eruption of a tooth as nearly normally in every respect as possible.

* Given at the meeting of the British Society of Periodontology held on May 21, 1960.

ERUPTED TEETH

Incisions.—The basic principles of flap design in oral surgery are generally accepted; but there is some divergence of opinion regarding the advisability of making incisions along gingival margins of erupted teeth, particularly when surgically removing impacted teeth. Considerable clinical judgement is required in some cases to decide whether to follow the gingival margin with an incision or to carry it parallel to it. In the majority of situations the former can be easily avoided and if a post-operative pressure pack cannot be applied, it may be wise to do so. For palatally impacted mesiodentes and maxillary canines, however, which are rarely away from gingival margins (Hitchin, 1956), it is my preference to follow these margins with incisions, and I have not noticed any periodontal breakdown arising as a sequel unless there is pre-existing periodontal disease. Kohler and Ramfjord (1960) investigated histologically the healing of gingival mucoperiosteal flaps in man and found no significant loss of periodontal attachment. Radden (1959), however, holds a contrary view, and has produced experimental evidence from work on monkeys showing some epithelial instability and proliferation down the root surface following such incisions. He does not state whether an antibiotic cover was used or palatal pressure packs applied, which in my opinion are advisable as well as careful suturing. Moreover, the disturbance of healing by the fingers of the monkey may be a significant factor. He advocates carrying the incision 3 mm. from the gingival margins; but as the mucoperiosteum must be undercut for suturing purposes, the undercut reaches to one millimetre or even less from the epithelial attachment. This is not an ideal situation. Moreover, trauma to incision margins may easily occur during tooth elevation in such circumstances. In short, the acceptance of the lesser of two evils may be the result of our clinical judgement in such cases.

THE PERIODONTIUM IN THE TREATMENT OF FRACTURED JAWS

Many forms of interdental wiring are used in the treatment of fractures of the jaws—most of them with the intention of using the intact opposite jaw as a splint. My personal preference in most of these cases, when adequate teeth are present, is for a modified type of eyelet wiring using soft stainless steel wire, and the objective should be to so tighten the twists that no further tightening is required subsequent to operation. To what extent are the gingivæ damaged permanently by eyelet wires? It seems possible that a loose one may do more harm than a tight one and a 0·7 or 0·8 mm. wire does no more damage than a thin one. To place eyelet wires so that they do not move, it is necessary to pierce the interdental papillæ, so that a pair of teeth is included as low as possible, well below their anatomical crowns. In my experience no harm to the gingivæ is caused if the interdental wiring is done boldly (*Figs.* 1 and 2), but the procedure is not easy in the conscious patient and its performance under general anæsthesia in theatre conditions is undoubtedly to be preferred.

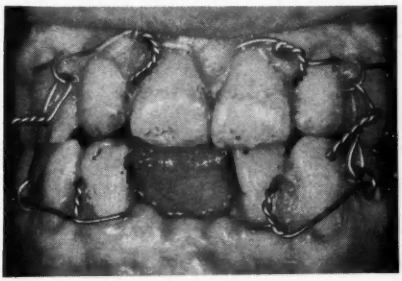

Fig. 1.—Eyelet wiring with 0·8 mm. stainless steel wire in a case of fracture of the mandible through the lower third molar region.

Fig. 2.—The teeth and gums in the case shown in *Fig.* 1, one week after the removal of the wires.

Well-constructed cap splints also do little harm to the gingivæ except when one or two teeth in a fragment have to withstand considerable displacing stress over long periods. This is only likely to occur when union is delayed or fragments are being maintained in position pending bone-grafting.

The tooth in the line of fracture is usually a periodontal problem—a problem which has been greatly modified by the use of antibiotics. At one time, there was general agreement that only unerupted teeth in lines of fracture have a sufficiently good prognosis to be left. To-day, we know from clinical experience that by control of infection, the pulp of a concussed tooth in line of fracture often recovers and may not be a cause of non-union. Nevertheless, a vertical pocket may persist, ultimately necessitating the extraction of the tooth. The use of antibiotics has changed the prognosis of such teeth, but clinical judgement is still required in their assessment.

ERUPTED TEETH INVOLVED IN CYSTS

It is not uncommon for vital erupted teeth to become involved in cysts which may be dental or dentigerous follicular in character. A radical approach to such teeth is not indicated unless they are involved in other pathological processes, rendering their prognosis poor. Beneath the cyst lining, the apical vessels and nerves to the involved vital teeth must be very superficial, and for this reason many have advocated marsupialization to avoid damaging them. For many years I have held the view that cyst linings are potential sources of danger—one being malignant change. For that reason I believe that, whereas linings may be retained after decompression of cysts for two or three months, they should be enucleated and submitted to biopsy.

There is a gathering body of opinion which supports this view.

The method used for enucleation is not without significance as far as the involved teeth are concerned. If curettage or scraping is performed on cyst walls with vessels and nerves just beneath the lining, then injury to them is likely to occur. If, on the other hand, after opening the cyst through an appropriate approach, the cavity is packed for about a minute with gauze soaked in 10 volumes hydrogen peroxide, the lining can usually be removed comparatively easily because of the surgical emphysema produced beneath it. In some cases, a second packing with gauze soaked in hydrogen peroxide after partial stripping may be helpful, but the adherent parts are almost always situated where the lining has become united to soft tissues, and it is in these areas that we would not expect to find apical vessels and nerves. In many cases, the lining can be removed whole. Apicectomy is performed on root-filled teeth that are involved and, provided antibiotic cover has been used, the wound can in most cases be closed, healing taking place by first intention.

At first, vital responses are not obtained if the markedly involved teeth are submitted to pulp testing; but a month or two later pulpal sensation normally returns. This occurred in the case shown in *Figs.* 3 and 4. The transient loss of sensation is presumably due to œdema around the nerves in the cyst wall. Bone regeneration proceeds at different speeds in different people, and various workers have used autogenous or homologous bone chips to hasten osteogenesis; whether bone chips are used or not, in due course the re-formation of a normal lamina dura around the vital involved teeth and the root-filled apicectomized teeth occurs—the re-establishment of normal periodontia.

There is some clinical evidence to show that more rapid restoration of an intact lamina dura takes place when an oblique apicectomy has been done rather than the more classical square-cut removal of the apex. Whilst oblique apicectomy is of particular value in the treatment of small globulo-maxillary cysts (*Figs.* 5 and 6), there are other situations in which it is useful. Indeed, on theoretical

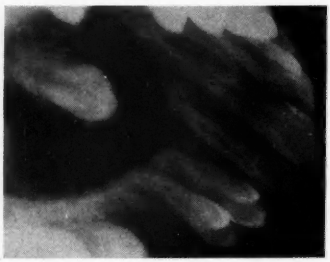

Fig. 3.—Lateral occlusal radiograph of the maxilla in a case of follicular cyst of the maxillary canine.

Fig. 4.—Lateral occlusal radiograph of the maxilla in the case shown in *Fig.* 3, 7½ years after enucleation of the cyst lining and removal of the canine. The standing teeth gave vital responses to pulp tests 9 months after operation. Rarefied area is due to a tunnel through bone from buccal to palatal side, but no clinical evidence of it is present.

Fig. 5.

Fig. 6.

Fig. 5.—Radiograph of a globulo-maxillary cyst with root-filled second incisor.

Fig. 6.—Radiograph of case shown in *Fig.* 5, 19 weeks after oblique apicectomy and enucleation of cyst.

grounds, one would expect more nearly normal stresses on newly-developing periodontal fibres, when the apex is as near conical as possible, and there is little doubt that in such circumstances a good lamina dura is more rapidly attained.

RADICULAR ABSORPTION OF STANDING TEETH

There are many causes of apical absorption, and all have to be considered in diagnosis, but one in particular is of special interest to the oral surgeon, for it is one in which he can remove the cause. I refer to that of the root of a standing tooth due to a tooth impacted against it. It is not without interest that when a maxillary canine is impacted against the second incisor absorption is uncommon, but when it is impacted against the first incisor absorption frequently occurs. This

Fig. 7. *Fig.* 8.

Fig. 7.—Radiograph of bilateral impacted maxillary canines with gross apical absorption of the first incisors.

Fig. 8.—Radiograph of the same case as *Fig.* 7, 12 months after the removal of the canines, the first incisors being still vital and attached by partial ankylosis.

difference is possibly due to the fact that in the case of the second incisor the apex is not closed when the canine becomes impacted against it, and the former can easily be moved by the pressure of the impacted tooth; whereas, because of its earlier development, the first incisor apex is already formed when the canine impinges upon its root.

When the cause can be removed, apical absorption does not necessarily present a hopeless prognosis as far as the standing tooth is concerned: after removal of the impacted tooth, attachment by ankylosis may occur, giving a sound functional tooth with a markedly resonant note on percussion, because the cushion of the periodontal membrane is absent, at least in part. Such a case is illustrated in *Figs.* 7 and 8. A sound functional

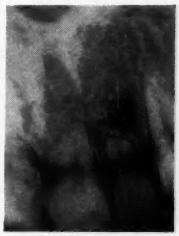

Fig. 9. *Fig.* 10.

Fig. 9.—Radiographs of an impacted maxillary canine with apical absorption (idiopathic) of the first and second incisors.

Fig. 10.—Radiograph of the opposite side in the same patient as *Fig.* 9 with idiopathic apical absorption of the first and second incisors.

periodontium in man is not necessarily that of a gomphosed attachment, though ankylosis is not, of course, normal.

It is, however, important, as always, for treatment to be based upon sound diagnosis, and when apical absorption apparently due to an impaction against an absorbed tooth is seen radiographically, it is important to examine other teeth to exclude so-called idiopathic apical absorption, which would almost certainly progress after the removal of the impacted tooth. Such a case is shown in *Figs.* 9 and 10, in which apical absorption of second incisors is seen both on the side with the impaction and also on the opposite side. If the impacted canine is removed in a case of idiopathic apical absorption, the latter will proceed and the unwary oral surgeon is liable to be blamed when the standing teeth fall out later. It is said, however, that root filling will prevent the absorption progressing.

Idiopathic apical absorption, as its name implies, is of unknown aetiology and is rare. The absence of local causes and the involvement of several teeth suggest a systemic factor, of which Stones (1951) states there is usually no concrete evidence, but of the 10

cases he recorded, one pair were sisters and another pair a brother and a sister, so that a genetic factor is a possibility. In a recent case of ours, a youth of 18 years, marked apical absorption was observed in $\frac{731|16}{|4}$ and to lesser degrees in other teeth.

There was a marked gingivitis not dissimilar to one of metallic origin, and this case

Fig. 11.

Fig. 12.

Fig. 11.—Radiograph showing apical absorption of the first incisors in a patient who also had Kinnear Wilson's disease.

Fig. 12.—Radiograph of maxillary premolar and molar regions in the same patient as *Fig.* 11.

was proved later to be one of hepatolenticular degeneration (Kinnear Wilson's disease), in which there is a disturbance of copper metabolism, with cupruria, decreased copper excretion in the stools, and a low total copper in both serum and blood with a deficiency of the enzyme coeruloplasmin (Bickel, Neale, and Hall, 1957). Copper deposits were demonstrated in biopsy specimens of the gingivæ and radiographs of some of the teeth are shown in *Figs.* 11 and 12. This condition is a disturbance of metabolism due to a recessive gene and it has been shown that, occasionally, relatives of such patients have a low serum copper, but are clinically normal.

Little appears to be known regarding general causes of apical absorption. Certainly, in hyperparathyroidism, root absorption does not occur. Illingworth and Gardiner (1955) recorded a case of premature absorption of deciduous teeth in which the only biochemical change noted was a low serum phosphatase. They did not state, however, whether the serum copper was investigated. Whilst it is impossible to prove correlation from one clinical case, nevertheless both idiopathic apical absorption and Wilson's disease are indeed rare and it is possible that the latter may be a cause of the former. Biochemical investigation of cases of idiopathic apical absorption and dental radiological investigation of cases of Wilson's disease are avenues worth pursuing to determine whether there is any association or whether the presence of both conditions in this case was purely fortuitous.

REPLANTATION

The replantation of standing teeth following their traumatic subluxation is by no means a new procedure. Fauchard (1745) certainly practised it. With a closed root apex, root filling is indicated prior to replantation, but root absorption is liable to occur (Burley and Crabb, 1960). Many are hesitant to replant a tooth which has been dislocated on a playing-field, because of the danger of spore-bearing organisms, whilst others regard this risk as slight, provided ordinary precautions, such as the administration of A.T.S., are adopted; but due to root resorption, results as far as time is concerned are not good. Friez (1960) has suggested the insertion of a vitallium post so shaped and inserted in the canal that it acts like a tenon after the root has been partially resorbed. There are some who advocate the removal of all periodontal fibres, hoping that re-attachment will take place by the laying down of new cementum with embedded Sharpey's fibres which remain attached to the lamina dura of the socket. Ankylosis may, however, occur either by inostosis following absorption or by the production of cementum on the root, united to bone.

TRANSPLANTATION

When a completely new socket is made by surgical means in cancellous bone and a tooth with the root still covered with periodontal fibres is inserted into it, clearly we cannot rely on existing periodontal fibres attached to a lamina dura, for this is absent. There is, however, a better blood-supply which may be

favourable. The transplantation of erupted teeth is rarely indicated, but of impacted teeth is worth considering, and will be referred to later.

INVOLVEMENT OF THE PERIODONTIUM BY MALIGNANT DISEASE

This is not, of course, uncommon in both carcinoma and sarcoma involving the alveolus. Clearly, conservation of teeth in such circumstances is out of the question, but the possibility of malignant involvement must not be ignored in periodontal diagnosis.

Deep X-ray therapy of oral tumours has its effect on the periodontium and in such patients close co-operation with the radiotherapist is indicated. There is not only the danger of early sloughing of the periodontium, but also the liability of bone sclerosis predisposing to necrosis as a post-operative sequel if extractions are performed many years later. The pre-radiation extraction of teeth in the area is undoubtedly in many cases a major contribution towards the prevention of such sequelæ.

THE SURGERY OF UNERUPTED TEETH

The oral surgeon has a great field of co-operation with the orthodontist: without it neither can render his full service. Essentially, much of it entails the surgery of the periodontium—the young developing periodontium with its wonderful power of recovery.

It is true that exodontia in cases of poor tooth–tissue ratio may be indicated. This, however, need not concern us in this paper. The oral surgeon is not often enough called upon to expose unerupted teeth with delayed eruption until it is late and the apex has formed. The removal of labial bone related to such teeth is usually contra-indicated (Broadway and Gould, 1960), but mere exposure of the incisive edges is usually not enough, and removal of the bone over the cingulum is advisable. Moreover, if the unerupted tooth is in malposition, the removal of a wedge of bone at its side may be indicated and contribute towards successful treatment. When supernumerary teeth causing impeded eruption of permanent teeth are removed, the removal of bone from over the crowns and particularly from over the cingula of the latter should be undertaken to hasten eruption, for so often the completion of their apices is imminent.

DENTIGEROUS FOLLICULAR CYSTS

When dentigerous follicular cysts are diagnosed before completion of the root formation of the teeth involved, then prognosis is quite good provided appropriate treatment is instituted reasonably quickly. There was a time when one preferred to open such a cyst via an alveolar approach and to incise the lining around the tooth followed by removal of the rest of the lining. This may still be advisable in some patients, but, in many, mere decompression is sufficient. This should be done in the line of eruption by excising a small area of mucoperiosteum and cyst lining in such a way that healing cannot take place. Regular observation and irrigation are advisable to prevent the accumulation of carbohydrate food pending eruption of the tooth which often takes place rapidly.

UNERUPTED AND IMPACTED TEETH

When impaction of permanent teeth is diagnosed before completion of their apices, there are two conservative lines of treatment which should be borne in mind: (*a*) The surgical movement of the impacted tooth without its removal, and (*b*) Its transplantation.

SURGICAL MOVEMENT OF IMPACTED TEETH

Whilst it may be true that suitable cases in which this procedure is indicated are not common, nevertheless, excellent results are sometimes obtained (Holland, 1956; Baden, 1956).

A successful example of surgical tooth movement is shown in *Figs.* 13, 14, and 15 in a girl of 10 years with gross impaction of the first and second maxillary incisors with apices still open. The second incisor was removed surgically and the first turned through 90°. Three years later this tooth was vital and in a good position, the maxillary canine having

descended and established good contact points with both the first incisor and the first premolar.

The apex must be open for the prognosis to be good and if the axis of movement is at the forming root-end, disturbance of blood-supply is less likely to occur.

molar socket so that it is about 1 mm. out of occlusion.

The results of transplantation of developing teeth vary, and clearly much remains to be learnt. When absorption occurs, it is possible that trauma to the developing tooth has been the initiating factor, for Fleming (1956) has

Fig. 13.

Fig. 14.

Fig. 15.

Fig. 13.—Radiograph of impacted first and second incisors with the apices open.

Fig. 14.—Radiograph of case shown in *Fig.* 13 after surgical removal of the second incisor and turning the first incisor through 90° with the end of the forming root as axis of movement.

Fig. 15.—Radiograph of same area as *Figs.* 13 and 14, 3 years later.

TRANSPLANTATION OF DEVELOPING TEETH

The transplantation of developing teeth has been the subject of considerable interest in oral surgical circles in recent years. Miller (1953), Clark, Tam, and Mitchell (1955), Emmertsen (1956), and Agnew and Fong (1956) have made significant contributions by clinical trials with autogenous transplants, whilst Pafford (1956) claims successful results from homologous transplants from a tooth bank in which the teeth are preserved in isotonic saline with small amounts of benzal konium chloride and tetracycline hydrochloride added, and kept in a deep freeze at —30° C. Agnew and Fong (1956) and Waite (1956) have done experimental work on autogenous transplants in monkeys and dogs respectively.

The prognosis for autogenous transplantation is much better when there is a wide open apex in a young patient, and the classical situation for such a procedure is the presence of an unsavable first molar in a patient of a little over 15 years with a developing lower third molar with the bifurcation just formed. The third molar is transplanted into the first

shown by his work on guinea-pigs that when the dental transplant is injured, mesenchymal cells invade it and prevent its development. Pafford (1956) considers the administration of antihistamines before surgery and for one week following homologous transplantation to be of great importance.

TRANSPLANTATION OF IMPACTED TEETH WITH APICES COMPLETED

The transplantation of impacted maxillary canines, after root filling, into artificially prepared sockets is a procedure that presents interesting possibilities provided a most careful selection of cases is practised. Usually, rapid attachment occurs with the production of a markedly resonant note on percussion, suggesting the development of ankylosis (*Figs.* 16 and 17). Nevertheless, root resorption may begin for no explained reason and rapidly progress. In one such case in a girl of 18 years, absorption began near the gingival margin 2 years after the transplantation of an impacted maxillary canine when every precaution had been taken to preserve a vital periodontal membrane on the root. The

absorption extended into the crown of the canine, and at operation the root was found to be ankylosed along the rest of its length and had to be removed piecemeal.

The causes of failure in a case such as this are not easily elucidated, but the very resilience of the periodontal membrane is surely of some importance. Even though the greatest care is taken to prevent traumatogenic occlusion, the absence of the cushion-like effect of the periodontal membrane causes stress on bone, which is quite unusual and may be a cause of absorption. Moreover, it is rarely possible to remove an impacted canine without slight trauma to its periodontal membrane and cementum and this may be the site at which absorption starts. There is, however, much in this field worthy of further investigation.

Fig. 16.

Fig. 17.

Fig. 16.—Radiograph of impacted maxillary canine prior to transplantation.

Fig. 17.—Radiograph of same area as shown in *Fig.* 16, 2 years later.

CONCLUSION

To the oral surgeon, therefore, the surgery of the periodontium is not only of great interest, but also requires considerable clinical judgement based upon a wide experience of conservative attempts to save and restore teeth. Moreover, it is a field that is actively expanding, and in which research will undoubtedly bear fruit both to the benefit of our patients and the satisfaction of those who pursue truth for its own sake, which, I trust, includes both oral surgeons and yourselves, the periodontologists.

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EDITORIAL [*continued from p.* 367]

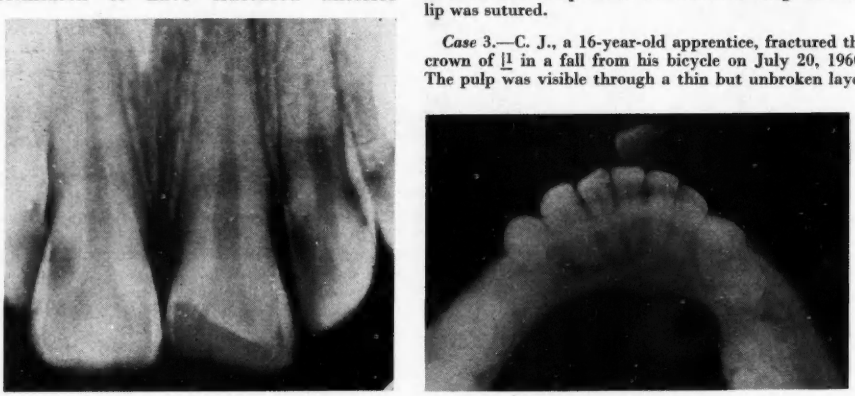
required for higher qualifications can produce a more versatile and more competent general practitioner. Such training will not, unfortunately, increase his earning capacity, but it will enable its possessor to gain more intellectual satisfaction from his profession and he will also inevitably render greater service to his patients.

The provision of a definite training programme for each registrar, and the broadening of such training for junior men, should fit them for a more adventurous form of practice. These steps, together with the giving of some thought to the cost of higher qualifications and the value of skilled men to the community, might do something to relieve what threatens to be a difficult situation.

INCISOR FRAGMENTS IN THE LIPS

By **FRANK J. ALLEN**, B.D.Sc. (Dubl.), F.D.S. R.C.S. (Eng.)
*Dental Department, Royal Victoria Infirmary, Newcastle upon Tyne**

THE presence of tooth fragments in the soft tissues of the lip is an occasional complication of maxillofacial injuries (Rowe and Killey, 1955). In childhood, injuries limited to incisors and lips are much more common than those involving the facial bones. Ellis (1948) found 4·2 per cent and Grundy (1959) 5·1 per cent of schoolchildren to have fractured anterior teeth and yet there have been few reports of the retention of tooth fragments in the lips of these patients. There is a possibility that foreign bodies of dental origin may be retained in the lips of such patients more frequently than is suspected. The following four cases seen in this department over a period of ten months indicate that a careful examination of the soft-tissue lacerations in this type of accident should always be carried out.



A B

Fig. 1.—*Case* 3. A, The crown of $\underline{|1}$ is fractured transversely with a near exposure of the pulp and is slightly subluxated. B, The fragment of the crown of $\underline{|1}$ is lying in the soft tissues of the lower lip.

CASE REPORTS

Case 1.—D. K., a 7-year-old boy, damaged his prominent anterior teeth in a cycle accident on Nov. 24, 1959. $\underline{1|1}$ were subluxated and the medial angle of the crown of $\underline{|2}$ fractured, the line of fracture passing through dentine. An associated full thickness laceration of his upper lip had been sutured prior to a request for a dental opinion. An anterior occlusal radiograph demonstrated that the missing portion of the crown of $\underline{|2}$ was embedded in the soft tissues of the lip from which it was removed without difficulty.

Case 2.—D. K., a 14-year-old girl, fell off her bicycle on May 11, 1960, fracturing the crowns of $\frac{1|2}{21|12}$ through the dentine and partially dislocating $\underline{|1}$ from its socket.

Clinical examination and surgical exploration revealed the presence of dental fragments in a penetrating laceration of her lower lip. After removal of the fragments the lip was sutured.

Case 3.—C. J., a 16-year-old apprentice, fractured the crown of $\underline{|1}$ in a fall from his bicycle on July 20, 1960. The pulp was visible through a thin but unbroken layer of dentine and the tooth was subluxated. He was found to have "bitten through" his lower lip and the lost fragment of the crown of $\underline{|1}$ was found in the laceration and removed prior to suture (*Fig.* 1).

Case 4.—H. C., a 7-year-old girl, fell on the pavement on Sept. 1, 1960, "biting through" her lower lip and chipping the incisal enamel of $\underline{1|1^2}$. The labial laceration had been sutured when she first attended the department, but radiography revealed enamel fragments within the repaired soft tissues and these were removed from the wound (*Fig.* 2).

No bony injury was present in any of the cases reported, the damage being confined to the teeth and lips. In each instance, the principles advocated by Ellis (1948) governed the emergency treatment of the injured teeth.

DISCUSSION

Each of the four patients sustained a full-thickness laceration of a lip extending from mucous membrane to skin, in association with

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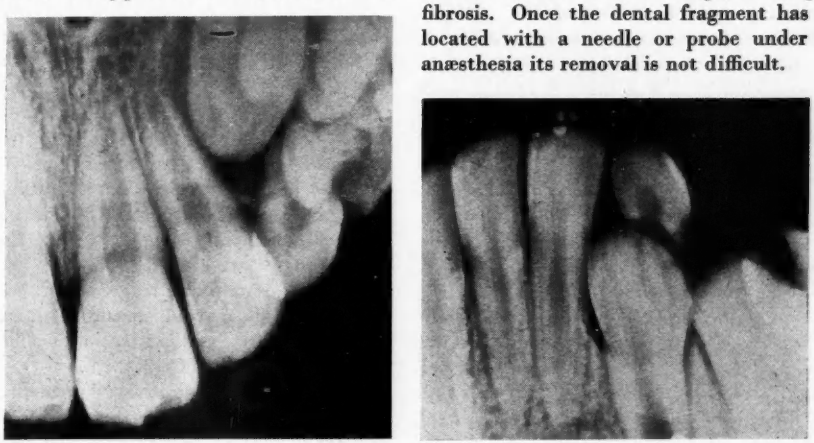
a fractured anterior tooth. In each case dental fragments were found in the involved lip. A possible explanation of these findings is that the tooth, having penetrated the full thickness of the lip, is fractured as it emerges from the skin surface on coming into direct contact with a hard object. The detached fragment of tooth is retained in the soft tissues which envelop it at the moment of impact.



A B

Fig. 2.—*Case* 4. A, The enamel incisal edges of $\underline{1|12}$ are chipped. B, Multiple enamel fragments are apparent in the soft tissues of the lower lip. The dental development of this 7-year-old child is well advanced.

Where enamel alone is involved it tends to shatter, and the presence of multiple fragments is to be anticipated (*Case* 4). Various factors, including the direction of the blow, the prominence of the anterior teeth, the length of the lip, and its position at the time of injury, determine which lip will be involved. The fact that in two of the cases labial lacerations had been repaired and dental fragments left in situ before a dental opinion had been sought emphasizes the ease with which these foreign bodies may be overlooked. Clinical examination is often hindered by œdema of the lip, and the value of the radiograph is stressed by Rowe and Killey (1955). Radiographic examination of the fractured anterior tooth alone is not sufficient in patients with an associated severe laceration of the lip. A soft-tissue radiograph of the damaged lip must be taken; the anterior occlusal view is most valuable.

The result of failure to remove portions of teeth embedded in the soft tissues may be breakdown of the suture line, persistent chronic infection and discharge, or disfiguring fibrosis. Once the dental fragment has been located with a needle or probe under local anæsthesia its removal is not difficult.

SUMMARY

Four children presenting with fractured incisors and associated full-thickness lacerations of the lips are reported. In each case dental fragments were discovered in the damaged soft tissues and removed surgically. A possible explanation of the mechanism underlying these clinical findings is offered, and the value of the radiographic examination of the lacerated soft tissues emphasized.

Acknowledgements.—I would like to thank Professor G. L. Howe for his advice and criticism during the preparation of this communication and Mr. A. J. Finlayson of the Photographic Department, Newcastle upon Tyne Dental Hospital, for the illustrations.

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BOOK REVIEWS

PRINCIPLES OF CLEFT PALATE PROSTHESIS. Aspects in the Rehabilitation of the Cleft Palate Individual. By CLOYD S. HARKINS, D.D.S., F.A.C.D., F.I.C.D., with the collaboration of WILLIAM R. HARKINS, D.D.S., F.A.C.D., F.I.C.D., and JOHN F. HARKINS, D.D.S., F.A.C.D., F.I.C.D. 10× 7⅝ in. Pp. 219+xvi, with 249 illustrations. 1960. New York: Columbia University Press; London: Oxford University Press. 96s.

CLOYD HARKINS has spent 42 years of his professional life in treating the cleft palate patient. He is internationally known to the dental profession by his demonstrations and lectures, while his articles and essays on this topic are freely available to all who would seek his help.

Consequently it is with real pleasure that we are at last able to read a book from his pen devoted to this relatively unknown topic—the prosthetic treatment of the cleft palate.

His two sons have collaborated with him in the production of the volume, and they, no doubt, count themselves fortunate in being associated with such an expert.

He has evolved his own methods of working, and he describes, in detail, his approach to each step in the construction of an obturator. This appliance is referred to as the Harkins' "speech aid", and its creation is amply illustrated both verbally and pictorially.

Case-history and record taking are described in considerable detail, and his record sheets make interesting reading.

The section on impression taking is particularly noteworthy. The palatal portions, both hard and soft, are recorded in alginate or hydrocolloid, but the pharyngeal portion is moulded with modelling compound, with a thin overlay of H.L.—a "thermoplastic impression material composed of natural and synthetic resins". This material is almost certainly unknown in this country at present, and is used where one or other form of gutta percha would be used here.

The H.L. coated speech bulb is removed from the mouth in a plastic state, and is hardened off by immersion in ice-cold water.

This chapter is of the utmost importance for, almost invariably in the past, this difficult task, the accurate pharyngeal moulding, a *sine qua non* in the prosthetic treatment of cleft palate, has been glossed over. It is the secret which must not be revealed. Harkins devotes many pages to it.

Detailed description is given of the construction of the partial denture with its cast metal framework, and instruction is offered on the correct clasping of the teeth.

Then follows a chapter on the construction of cast gold crowns and thimbles, inserted, probably, because the crowns are carefully shaped for the retention of a difficult prosthesis, and not for their exact anatomical reproduction.

Two chapters are devoted to the edentulous cleft. Again we get a very adequate description of the denture construction for the models illustrated, but one searches in vain for some of the methods of retention in common use in England. Deepening the sulcus is advocated, but can it be that, even with this extra surgery, every denture will be firmly retained without some additional mechanical aid?

Excellent chapters follow dealing with the treatment of children, depicting the construction of obturators which are also orthodontic devices, and demonstrating the excellent results which have been obtained in our authors' hands.

Many more pages are included giving valuable help for the prostheses necessary in acquired cleft palate, syphilitic, traumatic, or following surgery because of new growths.

Speech therapy and its valuable aid receive a chapter, and the authors leave one in no doubt that they know the importance of proper co-operation between prosthetist and therapist.

The book closes with various appendices depicting the record cards and forms in use in the Cleft Palate Clinic at Osceola Mills, under Dr. Harkins' care, and giving an adequate picture of the excellent treatment which is given to all the patients treated there.

Methods and material differ from operator to operator but the all-important end-result is the test of a man's work, and undoubtedly Cloyd Harkins and his collaborators are able to "produce the goods" very well. Their book very clearly depicts each step of the way they travel, and is a very welcome addition to dental literature.

Congratulations to authors and publishers alike. It is a good book.

R. D. G. G.

PRACTICAL ORTHODONTICS. By GEORGE M. ANDERSON, D.D.S., Sc.D., Formerly Professor of Orthodontics, Baltimore College of Dental Surgery, University of Maryland. Collaborator: P. A. DEEMS, D.D.S. Contributors: B. H. BROADBENT, E. A. KITLOWSKI, B. W. WEINBERGER, and C. F. WRIGHT. Ninth Edition. $9\frac{3}{4} \times 6\frac{3}{4}$ in. Pp. 738, with 719 illustrations. 1960. St. Louis: The C. V. Mosby Co. (London: Henry Kimpton). 135s.

THIS ninth edition by Anderson of *Practical Orthodontics* comes five years after the previous one. "Expansion in research and knowledge relating to the fields of etiology and diagnosis with special reference to genetic influences and the understanding of growth and developmental aberrations" is one reason for the new edition, in addition to "additional technical aids for the planning of rational therapy". Special value is attached to new ideas from abroad, among which are mentioned a skeletal classification of malocclusion, the use of removable plates, and the development of light wire forces. High hopes aroused by the Preface are not fulfilled on finding that the skeletal classification is by John Heath, sen., and that it is taken from an article dated 1955. C. F. Ballard was teaching a skeletal classification in 1948 at least. The section on removable appliances does no more than indicate that they exist, and a photograph on p. 424 of several continuous arrowhead clasps is captioned "the modified arrowhead clasp", thus causing confusion over a correct caption to a modified arrowhead (Adams') clasp on p. 386. Begg's technique is covered in half a page of text and 4 illustrations.

Some prominence is given to Ballard's views on muscle morphology and behaviour, though it is clear that they are not shared by the editor. European writers are fairly widely quoted in this edition for the first time, and it is evident that the editor is looking farther afield for his material. However, the book is far too unbalanced in its presentation of subject matter. A chapter of 57 pages by Weinberger is devoted to a historical résumé of the growth and evolution of orthodontics as against 4 pages on removable appliances in general, and those mostly photographs. The chapter on "The Edgewise Appliance", by Chester Wright, might have been written in 1932, and possibly was. For later knowledge one is referred to the literature. The chapter on "Plastic Surgery of the Jaws", by Kitlowski, was identical in the 1942 edition, and the most recent of the 31 references cited is dated 1933. Surely something worth mentioning has happened since then! And what is one to make of an editor who, on p. 27, shows lateral skull radiographs of a Class II, div. 1 malocclusion before treatment that has become a bimaxillary proclination as a result of treatment, the second radiograph taken with the appliance still in place and purporting to show "improvement following orthodontic therapy"?

To its credit the book is well produced with clear photographs. It has a valuable chapter by Broadbent on "The Measurement of Dento-facial Changes in Relation to the Cranium". Apart from those mentioned here as being by other contributors, the editor is responsible for the remaining chapters. The two on "Treatment of Malocclusion" are mostly concerned with labio-lingual methods, with rather primitive removable appliances often illustrated as an alternative. Any book of this size has much of interest in it, but it is not the balanced text on orthodontics for the student that still eludes all authors.

J. R. H.

SOME FACTORS CONCERNED WITH THE REDUCTION OF EXCESSIVE INCISOR OVERBITE IN ANGLE'S CLASS II, DIVISION 2 TYPE OF MALOCCLUSION

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INTRODUCTION

THE title of this paper is "Some Factors concerned with the Reduction of Excessive Incisor Overbite in Angle's Class II, division 2 Type of Malocclusion" with the emphasis on the word "some". Although an attempt has been made to cover several aspects of this subject there may be many other contributing factors as yet unknown.

Very rarely is any malformation or disease of any part of the body due entirely to one cause. It is more usual to find many influences which either work together to the same end, or are in opposition, and one cancels the effect of another to a varying degree. The result is a balance of these influences. Also, the body is not static, even in the adult state, and in childhood and adolescence is constantly changing. Factors present at one age may well be altered or absent at another, while other factors may have come into action which were not present earlier.

In treating malocclusions, at any given age it is impossible to predict a stable end-result without a thorough understanding of all the factors, viz,:—

1. Those present at the time of diagnosis.
2. Those arising as a result of, and during the course of, treatment.
3. Those arising during the period of treatment, but not connected with treatment, producing changes which would have occurred had there been no treatment at all.
4. Those that will be present at the end of treatment.

Some of these factors are favourable, some unfavourable, and some may well be favourable to one type of malocclusion but extremely unfavourable to another.

Interest in the factors involved in the problem of excessive incisor overbite was first aroused by one case where the result was better than in others of a similar type, although the original condition had seemed unpromising. This case was analysed, and then compared with other Class II, division 2 malocclusions, to try to discover the factors favourable in this instance.

CASE REPORT

The following is a report of the case of P. C., who appeared to have a better result than other Class II, division 2 cases of a similar type.

HISTORY.—P. C. was 12 years old when he first attended. He was of average size for his age. He seemed helpful and co-operative. His parents also showed good co-operation, as evidenced by their determination to travel over 50 miles each way for his treatment.

P. C. was more like his mother than his father in appearance. His mother was assessed as a skeletal Class II on clinical examination, while his father was a skeletal Class I or mild Class III. His mother had a Class II, division 2 type of malocclusion, but, owing to some loss of teeth, was difficult to assess. There was one younger brother, also a Class II, division 2 type, but less severe.

P. C. had no relevant medical history.

His previous dental history included removal of submerged $\overline{E}|$ and impacted $\overline{5}|$, and conservation, but no previous orthodontic treatment.

CLINICAL EXAMINATION.—

Soft Tissues.—Competent lips, habitually together, with a high lip line; teeth-together swallow with no clinically detectable abnormal lip or tongue action during swallowing; normal speech; no habits affecting the oral cavity; inter-occlusal clearance slightly increased, but with no evidence of forward posture of mandible; the path of closure of the mandible was centric.

Skeletal.—Class II with average to low Frankfort–mandibular plane angle.

Dental.—Oral hygiene was good; the gingivæ were normal with no traumatic effects from the incisal bite; caries was minimal and well treated (*Fig.* 1A).

Occlusion.—Class II, division 2; excessive incisor overbite with the mandibular incisors in light contact with the palatal mucosa; slightly increased overjet;

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Given at the meeting held on December 12, 1960.

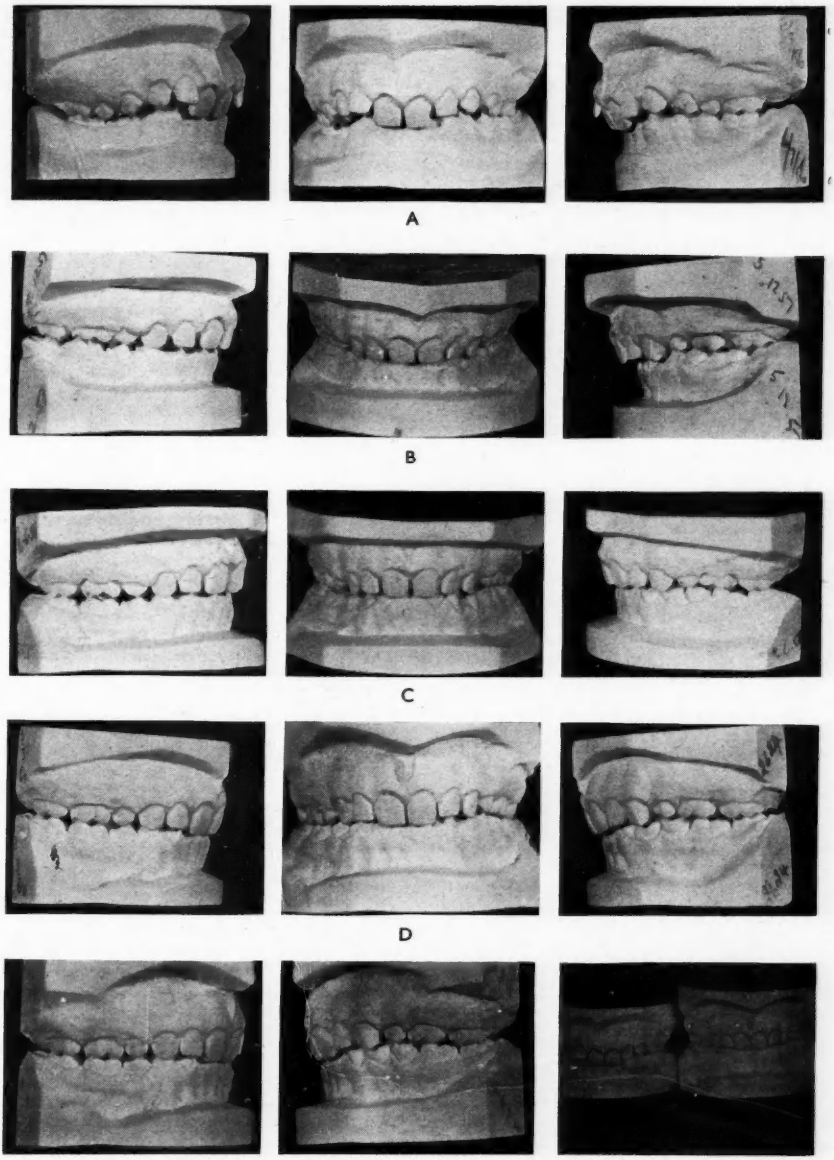


Fig. 1.—Models of P. C. A, Before treatment; B, After removal of fixed appliances; C, Six months later; D, At the end of retention; E, Six months out of retention; F, Model six months out of retention compared with original model.

retroclination of maxillary and mandibular incisors; anterior crowding in the maxillary arch; slight spacing in the mandibular arch was present, but the arch would have been crowded had $\underline{5}|$ been present; there was a shift of the mandibular centre line to the right; all teeth were erupted into the mouth except $\frac{87\ |78}{875|78}$; there was a buccal occlusion of $\underline{4}|\underline{4}$ with forward position of maxillary buccal segments.

RADIOGRAPHS.—

1. *Dental.*—These showed presence of $\frac{87|78}{87|78}$.

2. *Lateral Skull* (*Fig.* 2A).—This confirmed the clinical findings of skeletal Class II, retroclined maxillary and mandibular incisors, and low Frankfort–mandibular angle.

The readings are as follows:—

S.N̂.A. = 81·5°
S.N̂.B. = 74·5°
Difference = 7·0°

Maxillary incisors to Frankfort plane	= 91·0°
Maxillary incisors to maxillary plane	= 88·0°
Mandibular incisors to mandibular plane	= 79·0°
Angle between maxillary and mandibular incisors	= 168·5°
Frankfort–mandibular-plane angle	= 21·5°
Maxillary–mandibular-plane angle	= 26·0°
Gonial angle	= 117·5°
Nasion–sella–gnathion angle	= 69·0°
Overbite (orientated to Frankfort plane)	= 11·5 mm.
Overjet (orientated to Frankfort plane)	= 4·0 mm.

$$\frac{\text{Facial height (nasion–gnathion)}}{\text{Sella–gnathion}}\ \text{percentage} = \frac{115}{120} = 96\%$$

TREATMENT.—Treatment consisted of extraction of $\underline{4}|\underline{4}$ and complete multiband appliances to effect the following tooth movements, viz.:—

1. Retraction of $\underline{3}|\underline{3}$.
2. Alinement, vertical depression, and distal apical movement of $\underline{21}|\underline{12}$ (without proclination).
3. Closure of spacing in lower arch and depression of lower incisors with slight proclination. No attempt was made to restore symmetry in the mandibular arch.

The appliances consisted of modified Begg-type arches and the anchorage was intra-maxillary in the maxillary arch supplemented by inter-maxillary, to close spaces in the mandibular arch, and extra-oral traction at night.

Active treatment was completed in 13 months.

Passive arches were then inserted to retain for 2 months, after which time the bands were removed and upper and lower retention plates fitted immediately.

At this stage (*Fig.* 1B) it may be seen that, in spite of my intention not to procline the maxillary incisors, they have increased their angulation and there is an increase in overjet. The mandibular incisors have been depressed, relative to the posterior teeth, and proclined, and the overbite has been reduced. There is no contact between maxillary and mandibular incisors. The buccal segments have moved forward during treatment and $\underline{5}|\underline{5}$ are in poor contact. However, the spacing in the mandibular arch has been reduced and the alinement of anterior teeth is improved.

Altogether, the occlusion looks unstable and most unpromising.

RETENTION PERIOD.—The retention plates were worn by day and at night for 6 months. They consisted of fitted labial bows from $\frac{3+3}{3+3}$ with the plate fitting around the incisors palatally and lingually. The upper plate was thickened anteriorly to form a slight bite plane to maintain the vertical position of the mandibular incisors.

At the end of 6 months I examined P. C. again and found that, although he had been wearing the plates all the time as directed, there was some alteration in the occlusion. The overjet was decreased and the relationship of the posterior teeth had altered (*Fig.* 1C).

Another lateral skull radiograph was taken and compared with the one taken immediately after the bands were removed.

The readings are as follows, the figures in brackets being those of the radiograph immediately after treatment (*Fig.* 2 B, C):—

S.N̂.A. = 81·0° (81·0°)
S.N̂.B. = 75·0° (74·0°)
Difference = 6·0° (7·0°)

Maxillary incisors to Frankfort plane	= 92·0° (98·0°)
Maxillary incisors to maxillary plane	= 90·0° (95·0°)
Mandibular incisors to mandibular plane	= 81·0° (85·0°)
Angle between maxillary and mandibular incisors	= 158·0° (152·0°)
Frankfort–mandibular-plane angle	= 29·0° (25·0°)
Maxillary–mandibular-plane angle	= 30·0° (28·0°)
Gonial angle	= 119·0° (118·0°)
Nasion–sella–gnathion angle	= 71·5° (70·0°)
Overbite (orientated to Frankfort plane)	= 7·0 mm. (7·0 mm.)
Overjet (orientated to Frankfort plane)	= 3·0 mm. (5·0 mm.)

$$\frac{\text{Nasion–gnathion}}{\text{Sella–gnathion}}\ \text{percent} = \frac{139}{140} = 99\%\ \left(\frac{135}{135} = 100\%\right)$$

It may be seen from these figures that, although a relapse in proclination of maxillary incisors of 6° has occurred, the mandibular incisors have also relapsed by 4°, therefore the reduction in overjet is not entirely due to the falling back of the maxillary incisors.

A slight improvement of S.N̂.A.–S.N̂.B. difference is seen, although such a small difference may well be a tracing error.

The Frankfort–mandibular-plane angle, maxillary–mandibular-plane angle, and gonial angle have all increased slightly.

As I was not certain what was going to happen next, I decided to leave the retention plates and keep the case under observation. P. C. wore these plates day and night, the upper for 18 months and the lower for 1 year, after which time he went on to night-only retention for a further 6 months, retention being left off 6 months earlier in the lower arch. He was seen at intervals during this time, and the occlusion appeared to be steadily improving.

At the end of this period of retention, the incisors were in good contact, although the overbite was still deeper than normal. They were in a position of compromise to their angulations (*Fig.* 1 D).

The buccal relationships are not perfect, due to asymmetrical loss in the mandibular arch.

The case was re-assessed and it was found that his soft-tissue morphology and behaviour were similar to those noted at his diagnosis 3 years earlier, i.e., normal. The

inter-occlusal clearance and path of closure of mandible were normal and centric. The lip line was still high, however (*Fig.* 3 A–C).

Physically, apart from his dental condition, considerable changes had occurred. His height had increased markedly (he was now 5 ft. 11 in.) and he was showing signs of development and maturation—deepening of the voice and the beginning of the growth of facial hair.

Six months after retention was discarded there was, if anything, a further improvement in occlusion. A

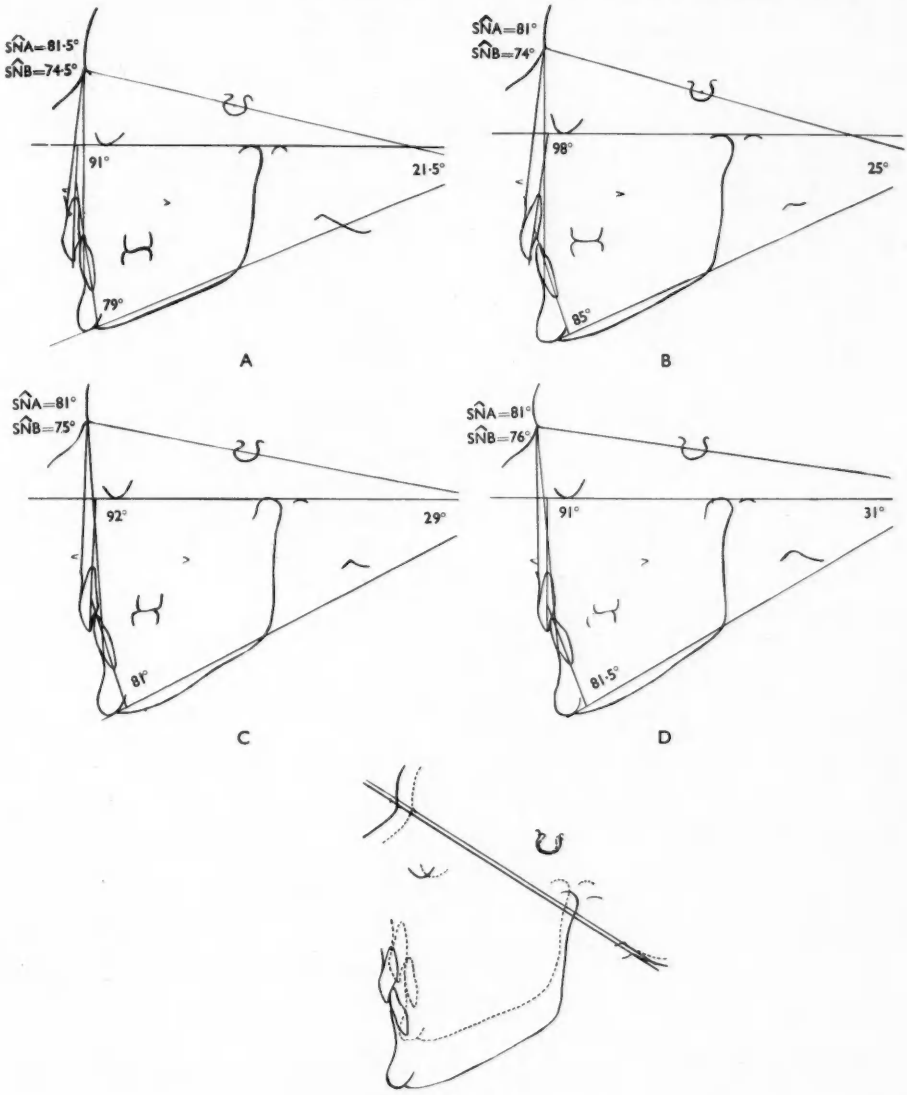


Fig. 2.—P. C.'s lateral skull tracings. A, Before treatment (12 years); B, After active treatment (13 years); C, During retention (14 years); D, Six months after retention (16 years); E, Superimposition of A and D.

follow-up lateral skull radiograph was taken, which showed the following measurements (*Fig.* 2 D):—

S.N̂.A. = 81·0°
S.N̂.B. = 76·0°
Difference = 5·0°

Maxillary incisors to Frankfort plane	= 91·0°
Maxillary incisors to maxillary plane	= 87·0°
Mandibular incisors to mandibular plane	= 81·5°
Angle between maxillary and mandibular incisors	= 156·5°
Frankfort–mandibular-plane angle	= 31·0°
Maxillary–mandibular-plane angle	= 34·0°
Gonial angle	= 122·0°
Nasion–sella–gnathion angle	= 72·0°
Overbite (orientated to Frankfort plane	= 7·0 mm.
Overjet (orientated to Frankfort plane)	= 2·0 mm.

$$\frac{\text{Nasion–gnathion}}{\text{Sella–gnathion}}\ \text{percentage} = \frac{140}{143} = 98\%$$

The appearance is shown on models (*Fig.* 1 E).

The case has now been out of retention for about 1 year. It is stable, and, if anything, still improving slightly. P. C. is now nearly 16 years old.

There appears to be a slow, gradual increase in the Frankfort–mandibular, maxillary–mandibular, gonial, and nasion–sella–gnathion angles.

The overbite, once reduced, is maintained and the overjet is improved.

The slight alteration in $\frac{\text{nasion–gnathion}}{\text{sella–gnathion}}$ percentage may indicate an alteration in direction of growth from vertical to anterior-posterior and then swinging back to vertical.

SUMMARY

The factors favourable and unfavourable to reduction of overbite in this case may be considered under the headings mentioned in the introduction.

1. Factors present at the Time of Diagnosis.—

a. Favourable.—(i) Normal soft tissues; (ii) Good condition of teeth and mouth; (iii) Co-operation good.

Table I.—Comparison of Measurements from P. C.'s Lateral Skull Tracings

Measurement	1	2	3	4
S.N̂.A.	81·5°	81·0°	81·0°	81·0°
S.N̂.B.	74·5°	74·0°	75·0°	76·0°
Difference	7·0°	7·0°	6·0°	5·0°
Maxillary incisors to Frankfort plane	91·0°	98·0°	92·0°	91·0°
Maxillary incisors to maxillary plane	88·0°	95·0°	90·0°	87·0°
Frankfort–mandibular-plane angle	21·5°	25·0°	29·0°	31·0°
Maxillary–mandibular-plane angle	26·0°	28·0°	30·0°	34·0°
Mandibular incisors to mandibular plane	79·0°	85·0°	81·0°	81·5°
Gonial angle	117·5°	118·0°	119·0°	121·5°
Nasion–sella–gnathion angle	69·0°	70·0°	71·5°	72·0°
Overbite	11·5 mm.	7·0 mm.	7·0 mm.	7·0 mm.
Overjet	4·0 mm.	5·0 mm.	3·0 mm.	2·0 mm.
$\frac{\text{Nasion–gnathion}}{\text{Sella–gnathion}}$ percentage	96	100	99	98

1, Before treatment (12 years); 2, After active treatment (13 years); 3, During retention (14 years); 4, Six months after retention (16 years).

A comparison of models will show the changes in occlusion (*Fig.* 1 F), and a comparison of lateral skull tracings (*Fig.* 2 E) will show the changes seen on radiographs.

Table I shows the changes in lateral skull tracing measurements.

It can be seen that there has been a very slight improvement in S.N̂.A.–S.N̂.B. difference.

The maxillary incisors have been proclined and then returned to their original angulation. There was believed to be some distal movement of apices, which is difficult to demonstrate on radiographs.

The mandibular incisors were proclined and then relapsed again, but maintained a slight proclination of 3·5°.

Depression of maxillary and mandibular incisors was difficult to demonstrate, but appeared to be more in the mandibular arch.

b. Unfavourable.—(i) Skeletal Class II; (ii) Low Frankfort–mandibular-plane angle (believed to be associated with increased overbite); (iii) Early loss of $\underline{5}|$; (iv) Buccal occlusion of $\underline{4|4}$ and post-normal occlusion; (v) Retroclination of upper and lower incisors and an already excessive incisor overbite with palatal contact; (vi) Distance which patient had to travel.

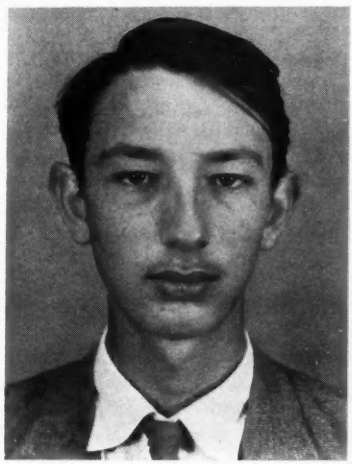
At first the picture was not encouraging.

2. Factors arising as a Result of Treatment.—

a. Favourable.—(i) Appliances well tolerated and patient very co-operative; (ii) Decision

to accept an asymmetrical mandibular arch prevented further collapse of labial segments; (iii) It was possible to depress and procline the mandibular incisors, and to provide contacts to support the labial segments.

b. Unfavourable.—(i) Proclination of maxillary incisors prevented a contact being made between upper and lower incisors to maintain the overbite; (ii) The asymmetrical loss in the lower arch, together with symmetrical loss in the upper arch, prevented a good buccal occlusion from being produced; (iii) The upper buccal segments were moved forward during treatment.



A

B

C

Fig. 3.—Photographs of P. C. at the end of retention. A, Full face; B, Left profile; C, Occlusion.

3. Factors arising during the Period of Treatment which might have occurred had there been no Treatment at all.—

a. Favourable.—(i) Decrease in S.N̂.A.–S.N̂.B. difference; (ii) Increase in Frankfort–mandibular and maxillary–mandibular angles may have improved the incisor relationship; (iii) The alteration in the percentage $\frac{\text{nasion–gnathion}}{\text{sella–gnathion}}$ may show a greater downward growth; (iv) General increase in height and development.

b. Unfavourable.—None were found in this case. All the tendencies appeared to favour improvement.

4. Factors present at the End of Treatment.—

a. Favourable.—(i) The retention period was obviously favourable in this case. Had the mandibular incisors not been held in the vertical plane they may well have over-erupted again; (ii) The relapse of incisors into muscle balance as well as into contact helped to make the case stable. The upper incisors were at the same inclination as at the beginning of treatment; (iii) Cuspal contacts on the posterior

teeth may have, by inclined plane action, aided the settling of the occlusion and may have produced some forward element; (iv) Muscle action on the proclined maxillary incisors may have moved the entire maxillary arch distally;

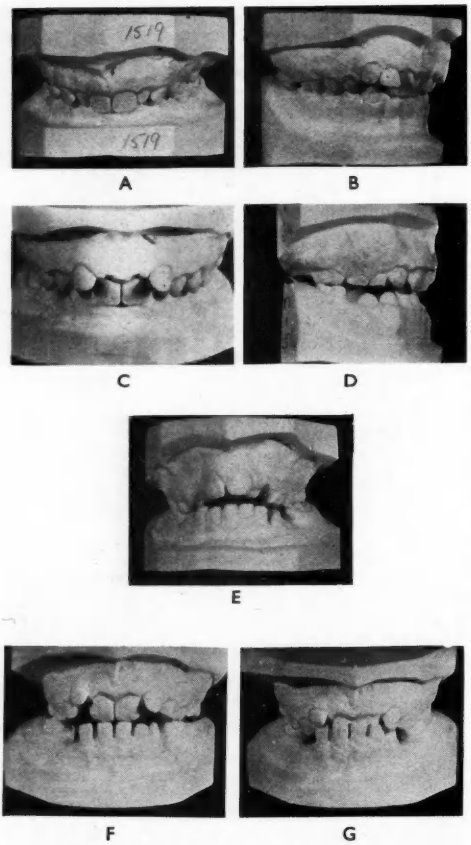


Fig. 4.—Models of different types of Class II, division 2 cases. A, Very deep incisor overbite; B, Extreme overcrowding; C, Very proclined lateral incisors; D, Reduced anterior overbite; E, Anterior open bite; F, Reversed overjet—open; G, Reversed overjet—closed.

(v) Growth may have brought the lower arch forward (certainly there was no forward bite of accommodation in this case at the end of treatment); (vi) The improved skeletal relationships may have aided improvement.

b. Unfavourable.—The overjet which, had there been no retention, might have resulted in relapse into an extreme excessive incisor overbite again.

Thus it can be seen, in this particular case, that an unfavourable beginning with, apparently, many unfavourable factors present, could still result in an acceptable end-product by the emergence of favourable factors to balance these already present.

Having examined one case, it was thought that it might be interesting to investigate more Class II, division 2 cases and to follow through as many as possible in order to try to find favourable factors common to all cases and predictable from the beginning of treatment. It was decided, therefore, to select cases for comparison.

SELECTION OF CASES FOR COMPARISON

One hundred and five cases of Class II, division 2 type were selected from patients under treatment at the Royal Dental Hospital and the Hospital for Sick Children. Sixty-nine of these were under my own care. I chose those classified as Class II, division 2 on clinical examination, with at least half a unit of post-normality of the posterior occlusion and with retroclined maxillary incisors. The ages ranged from 11 to 14 years inclusive. Severe cases under permanent retention were discarded.

At first, the original models were examined. It was interesting to note how many different types of malocclusion fall into this class, and it was realized how artificial these accepted classifications may be, although they are convenient (*Fig.* 4).

Next, the original lateral skull radiographs were traced and examined. It was then found that some cases, although classified as division 2 type by clinical investigation, were really division 1 type from tracings. This was due to the abnormal angulation of crown to long axis, which made the teeth appear to be retroclined.

This was seen in many cases, although in most of them the long axis was retroclined as well, and these could still be included in the selected group. As some other workers are at

present investigating this field, I shall not discuss crown–root angulation further at this point.

As well as using original models and lateral skull tracings, the soft tissues were also recorded clinically at the time of diagnosis.

ANALYSIS OF 105 CASES

Occlusal.—The analysis of occlusions may be seen in *Table II A, B*. These figures were produced from a study of models and lateral skull tracings.

In *Table II A* the labial segments were analysed under the following headings, viz.:—(1) Angulation of incisors; (2) Overbite and overjet; (3) Contact made by mandibular incisors; (4) Abnormal or absent teeth; (5) Degree of crowding or spacing; (6) Position of mandibular centre line.

1. *Angulation of Incisors.*—It may be seen from these figures that all the maxillary central incisors in these cases were retroclined. They were all angulated at less than 104° to the Frankfort plane, the normal being taken as 105°–111° to the Frankfort plane. This plane was used because of its clinical significance. Measurements were also made to the maxillary plane and almost identical results were found, except in the few cases where the two planes were divergent.

The readings are divided in an arbitrary manner merely to show the range covered. Similarly, the readings for mandibular incisor angles to mandibular plane are arbitrarily divided.

The mandibular incisors were largely retroclined, although many only slightly. Thirteen cases had proclined lower incisors. The normal was taken as 90° ±4° to the mandibular plane.

2. *Overbite* (orientated to Frankfort plane).—Particular attention was paid to determining the degree of overbite. The overlap of incisors, from incisal tips of the maxillary central incisors to the incisal tips of the mandibular central incisors, was measured in millimetres. Where there was a discrepancy in length, the mean was taken. Then the labial surfaces of the clinical crowns of the mandibular central incisors were measured in mm. and, again, the mean was taken if there was a discrepancy in length. Then the proportion of overlap to crown length was found. The normal was taken as $\frac{1}{4}$–$\frac{1}{3}$. Actual measurements were not used at this stage, as an overlap of a certain measurement may be normal on a large tooth but excessive on a small tooth, and great variation in tooth size was found. It may be seen from the figures that nearly all the cases (95/105) had an overbite greater than $\frac{1}{3}$ of the length of the clinical crown of the mandibular incisor. Eight had a normal overbite and 2 had reduced or open bite. That great differences were found can be seen on these two lateral radiograph tracings (*Fig.* 5 A, B).

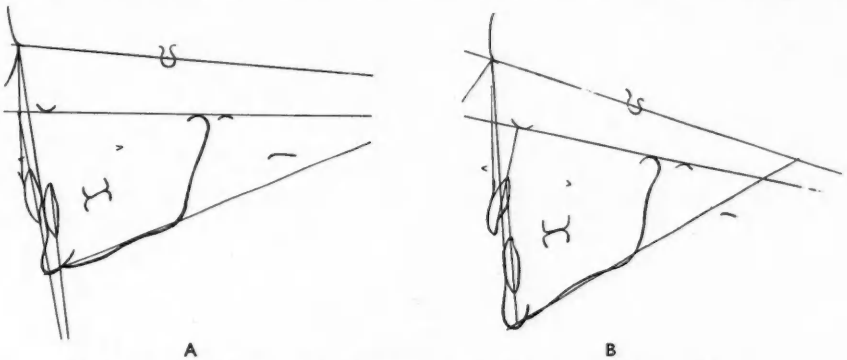


Fig. 5.—Tracings of two Class II, division 2 cases. A, With extreme incisor overbite; B, With anterior open bite.

3. *Overjet* (orientated to Frankfort plane).—This was measured as the distance from the tip

Table II.—Analysis of Occlusions of 105 Class II, division 2 Cases

A. LABIAL SEGMENTS

Measurement		No. of Cases (105)
Angulation of maxillary incisors	<85°	14
	86°– 95°	35
	96°–104°	36
	105°<	—
Angulation of mandibular incisors	<75°	19
	76°–85°	30
	86°–94°	43
	95° <	13
Contact of mandibular incisors	With maxillary incisors	59
	With palatal mucosa	36
	None	10
Overbite	Increased	95
	Normal	8
	Decreased	2
Overjet	Increased	17
	Normal	85
	Decreased	2
	Reversed	1
Crowding	Maxillary	86
	Mandibular	68
Spacing	Maxillary	4
	Mandibular	6
Abnormal teeth	Reduced lateral incisors	2
	Increased crown/root angle	55
Absent teeth	Absent lateral incisors	2
Mandibular centre line not coincident with maxillary		63

B. BUCCAL SEGMENTS

Measurement			No. of Cases (105)
Premature loss	Deciduous	Maxillary	24
		Mandibular	36
	Permanent	Maxillary	9
		Mandibular	11
Post normality	½ unit		65
	1 unit		31
	More than 1 unit		9
Crowding	Maxillary		29
	Mandibular		32
Spacing	Maxillary		7
	Mandibular		8
Cross-bite	Right		4
	Left		7

of the maxillary central incisors to the labial surface of the mandibular central incisors. The normal was taken as 2 mm. Eighty-five cases were found to have a normal overjet, 17 were increased, 2 reduced, and 1 actually reversed (*Fig.* 4).

3. *Contact made by Mandibular Incisors.*—The contact made by the mandibular incisors was assessed according to whether they touched the maxillary incisors or palatal mucosa or nothing at all, when the posterior teeth were in occlusion. Most of the cases had contact with teeth, the deeper ones with palatal mucosa, and a few were actually causing stripping of the gingivæ. Ten cases had no contact at all.

The cases previously mentioned as having normal or reduced over-bite fall into the same group of 10 cases mentioned here as having no contact. This group is peculiar, and will be discussed further when more aspects of the cases are examined.

4. *Abnormal or Absent Teeth.*—Two cases had absent lateral incisors. Another 2 cases had lateral incisors of reduced size. Fifty-five cases had abnormal crown–root angulation.

5. *Crowding and Spacing.*—It was found that nearly all the cases were crowded in the maxillary labial segment (86/105) and very few spaced (4). In the mandibular labial segment, 68 were crowded and 6 spaced.

6. *Centre Line.*—The centre lines were not coincident in 63 of the cases.

Table III.—Analysis of Skeletal Patterns of 105 Class II, division 2 Cases

Measurement		No. of Cases (105)
Classification	I	36
	Mild II	55
	Severe II	9
	III	5
Frankfort–mandibular-plane angle	<24°	26
	25°–30°	57
	31°<	22
Maxillary–mandibular-plane angle	<24°	23
	25°–30°	52
	31°<	30
Gonial angle	<119°	39
	120°–125°	48
	126°<	26
Nasion–sella–gnathion angle	<66°	27
	67°–71°	52
	72°<	26
$\frac{\text{Nasion–gnathion}}{\text{Sella-gnathion}}$ percentage	<97	21
	98–102	56
	103<	28

The buccal segments were then analysed (*Table II B*) under the following headings: (1) Premature loss of teeth; (2) Degree of post-normality; (3) Crowding or spacing; (4) Cross-bites.

1. *Premature Loss of Teeth* (Posterior).—Premature loss of deciduous and permanent teeth was noted in mandibular and maxillary arches. The permanent teeth lost were mainly first molars, although two first premolars were prematurely lost in one case.

2. *Degree of Post-normality.*—This was measured in units, one unit being the mesio-distal width of the first premolar. No cases had less than ½ unit of post-normality.

3. *Crowding or Spacing.*—As with the labial segments, very few cases showed spacing, more were crowded.

4. *Cross-bites.*—Very few cases had cross-bites, and those noted were individual teeth rather than the whole segment.

Skeletal.—The skeletal analysis of 105 cases is shown in *Table III.*

The following measurements were made:—

1. *Skeletal Classification.*—This was assessed clinically and verified with lateral skull radiograph tracings. On the tracings, the skeletal patterns were found by correction of angulation of incisors and by S.N̂.A.–S.N̂.B. difference measurements. The S.N̂.A.–S.N̂.B. difference measurements were then taken as follows:—

	Sk. I	=Difference 2°–4°
Mild	Sk. II	=Difference 5°–7°
Severe	Sk. II	=Difference 8°<
	Sk. III	=Difference <1°

Most were Sk. II and Sk. I, but not many Sk. III or severe Sk. II.

2. *Frankfort–mandibular-plane Angles and Maxillary–mandibular-plane Angles.*—These were divided arbitrarily to show the range covered and seemed fairly evenly divided amongst the groups, not necessarily having low values.

3. *The gonial angle* was measured, which again showed considerable variation.

4. *The nasion–sella-gnathion angle* was measured to attempt to predict the direction of growth. The results were again spread over a wide range.

5. *The percentage* $\frac{\textit{nasion–gnathion}}{\textit{sella –gnathion}}$ was used to attempt to show variations in growth from vertical to forward and downward. These values again varied considerably. Percentages were used to avoid errors possibly introduced by variations in radiographs.

Soft Tissues.—The soft-tissue morphology and behaviour is shown in *Table IV.* The following points were investigated: (1) Lip line; (2) Lip posture; (3) Swallowing action; (4) Habits; (5) Speech; (6) Inter-occlusal clearance; (7) Mandibular posture; (8) Path of closure of mandible.

1. *The lip line* was taken as normal if it lay at the junction of the incisal $\frac{1}{3}$ and gingival $\frac{2}{3}$ of the labial surface of the maxillary incisors. Nearly all the cases had high lip lines.

2. *Lip Posture.*—It is unfortunate that we had no way of recording musculature except by making notes of clinical findings. It is impossible to check these as it is with models or radiographs. On checking the follow-up cases I am sure that ideas and clinical assessment may have changed during the intervening years since some of the cases were originally assessed. Thus, cases originally called "competent" may now be called "slightly incompetent, habitually together". Therefore I publish the findings, but with the reservation that they may not be quite accurate.

3. *Swallowing Action.*—Again, observations made at the time of diagnosis may be interpreted differently at the present time, but the figures shown should give a rough estimate of the different types. It may well be that at this time the contraction of lips prior to swallowing (to collect saliva) may have been misinterpreted as contraction actually during swallowing. However, the cases noted as having tongue thrusts fit in with the cases with no incisal contact, which is interesting.

4. *Habits.*—Very few of these patients had sucking habits of any kind, nor were any remembered during earlier years. However, we should remember that patients' memories are not always reliable.

5. *Speech.*—This was not checked in any expert fashion, but sounds were noted during the course of conversation. No abnormalities were found.

6. *Inter-occlusal Clearance, Mandibular Posture, and Paths of Closure.*—Again, these are factors which may not have been recorded in each case, which would, I think, explain the low numbers.

At first sight, remembering that all but 10 of the cases had increased incisor overbite, it would appear that there is little correlation between overbite and other factors. The skeletal, occlusal, and soft-tissue analyses seem to vary so much, and few factors seem to stand out as being invariably present.

However, the two extremes, i.e., those with normal or reduced overbite and those with really deep overbite, with palatal contact, were separated and further investigated. It was felt that factors associated with the normal or reduced may well be favourable to reduction of overbite. Factors associated with the very deep might prove to be a guide to the unfavourable factors.

It was found that the only factor persistently present in the cases of normal or reduced overbite was abnormal soft-tissue behaviour and habits, i.e., tongue thrusting and sucking habits. All other factors appeared to be the same as in the main group. Thus it seems that, in abnormal circumstances, a further abnormal factor is likely to counteract other abnormal forces and produce a more normal result. However, it must be remembered that there was no incisal contact in these cases.

In the extreme cases with palatal contact no one persistent factor was found which was present in every case, which is interesting, as this means that an increased overbite is due not to one factor only but to many and not always the same ones. The following findings may be interesting: of these cases (36):—

1. Eighty-seven per cent had a Skeletal II base (not necessarily severe).
2. Seventy-five per cent had a tooth-apart swallow with some contraction of the circumoral musculature.
3. Sixty-seven per cent had early loss of units in the mandibular arch.
4. The retroclination of incisors was of the more severe type.
5. More of the cases had a more severe type of post-normality of posterior occlusion.

However, with only 10 cases of one type and 36 of the other, it is not possible to show anything but a tendency to an association.

Table IV.—Analysis of Soft Tissues of 105 Class II, division 2 Cases

Soft Tissues		No. of Cases (105)
Lip line	Normal	12
	High	93
Lip posture	Competent	66
	Incompetent	39
	Habitually together	94
	Habitually apart	11
Swallowing action	Teeth together	64
	Teeth apart	41
	Contraction of lips	77
	Anterior tongue thrust	10
Habits	Thumb-sucking	3
	Lip-sucking	1
Speech	Anterior sigmatism	—
	Dislalia	—
Inter-occlusal clearance	Normal	71
	Increased	34
Posture of mandible	Normal	71
	Forward	10
	Open	24
Path of closure of mandible	Protrusive	1
	Lateral	4
	Centric	87
	Retrusive	13

Table V.—Comparison of Occlusions Before and After Treatment in 49 Cases

A. LABIAL SEGMENTS

Measurement		Overbite Reduced (27)		Overbite Unchanged (12)		Overbite Increased (10)	
		1st	2nd	1st	2nd	1st	2nd
Angulation of maxillary incisors	<85°	4	3	3	2	2	2
	86°–95°	11	12	5	6	3	2
	96°–104°	12	12	4	4	5	6
	105°<	—	—	—	—	—	—
Angulation of mandibular incisors	<75°	5	3	1	1	1	2
	76°–85°	8	10	4	6	4	1
	86°–94°	10	7	3	3	5	6
	95°<	4	7	4	2	—	1
Overjet	Increased	1	—	1	—	1	4
	Normal	25	27	11	12	9	6
	Decreased	1	—	—	—	—	—
Crowding	Maxillary	24	6	10	2	9	1
	Mandibular	24	12	10	5	9	2
Spacing	Maxillary	—	—	1	1	—	—
	Mandibular	1	—	—	2	1	7
Contact of mandibular incisors	with maxillary incisors	12	24	6	6	7	4
	with palatal mucosa	12	—	5	5	3	6
	None	3	3	1	1	—	—
Abnormal or absent teeth	Reduced lateral incisors	—	—	—	—	—	—
	Increased crown/root angle	12	12	6	6	8	8
	Absent incisors	—	—	1	1	—	—
Mandibular centre line not coincident with maxillary		12	10	4	6	5	7

B. BUCCAL SEGMENTS

Measurement			Overbite Reduced (27)		Overbite Unchanged (12)		Overbite Increased (10)	
Premature loss	Deciduous	Maxillary	9		2		4	
		Mandibular	10		2		6	
	Permanent	Maxillary	2		1		—	
		Mandibular	2		—		—	
Unit of post-normality	½ unit		15		7		2	
	1 unit or more		12		5		8	
			1st	2nd	1st	2nd	1st	2nd
Crowding	Maxillary		12	2	1	—	2	—
	Mandibular		23	12	2	—	1	—
Spacing	Maxillary		1	5	2	—	1	—
	Mandibular		2	—	1	4	1	4

ANALYSIS OF TREATED CASES

From the 105 cases analysed above, 49 were followed through treatment into the post-retention period. Several cases had been two or three years out of retention when re-called—some less, but every case had been at least six months out of retention. The loss of cases was due mainly to patients discontinuing treatment for various reasons or to their not reporting for the final check-up.

The 49 cases were examined for reduction of incisor overbite when compared with the original models. This time actual measurements in mm. of the vertical distance between the maxillary and mandibular incisal tips were noted and compared with the original distance. Proportions could not be used because gingival recession had occurred in some cases which would make the clinical crown larger, thus disturbing the values for the proportions.

The cases were then divided into three groups:—

1. Those where a reduction of overbite had been achieved and maintained in the post-retention period.

2. Those where the overbite was exactly the same as at the beginning of treatment, although the rest of the occlusion may have been greatly improved.

3. Those where the excessive overbite had actually increased, i.e., become worse, in spite of improvement in the occlusion otherwise.

27/49 were in the first group; 12/49 were in the second group; 10/49 were in the third group.

The final grouping showed little relation to the original degree of overbite except in the very severe cases which were in the second or third group.

These 49 cases were then analysed according to the above grouping, for occlusal, skeletal, and soft-tissue variations.

Occlusal.—*Table V A* shows the comparison of labial segments before and after treatment, the first column in each group being

Table VI.—Comparison of Soft Tissues Before and After Treatment in 49 Cases

		Overbite Reduced (27)		Overbite Unchanged (12)		Overbite Increased (10)	
		1st	2nd	1st	2nd	1st	2nd
Lip line	Normal	3	5	—	—	—	—
	High	24	22	12	12	10	10
Lip posture	Competent	27	20	10	8	10	2
	Incompetent	—	7	2	4	—	8
	Habitually together	27	27	10	12	10	10
	Habitually apart	—	—	2	—	—	—
Swallowing action	Teeth together	10	15	7	8	4	2
	Teeth apart	17	12	5	4	6	8
	Contraction of lips	20	12	12	8	10	10
	Anterior tongue thrust	2	2	—	—	—	—
Habits	Thumb-sucking	—	—	—	—	—	—
	Lip-sucking	—	—	—	—	—	—
Inter-occlusal clearance	Normal	27	27	10	10	2	—
	Increased	—	—	2	2	8	10
Posture of mandible	Normal	27	27	10	10	2	—
	Forward	—	—	2	2	6	7
	Open	—	—	—	—	2	3
Path of closure of mandible	Protrusive	—	—	—	—	—	—
	Retrusive	—	—	2	2	6	7
	Lateral	—	—	—	—	—	—
	Centric	27	27	10	10	4	3

before treatment, the second column after treatment.

The incisal angulations do not seem to bear much relationship to the reduction achieved. Similarly, the figures for overjet and crowding seem to be almost identical in all three groups.

The figures for incisal contact are more definite, the cases in the first group all resulting in tooth contact except those where there was no contact originally. These 3 odd cases did, however, show a reduction, although they were normal to start with, and this reduction was maintained. In the second group the contacts are the same and in the third group the contacts are worse.

Figures for abnormal teeth and centre line do not seem to be significant at all.

Table V B shows the comparison of buccal segments.

The original state of premature loss does not seem to have any effect on the end result.

The degree of post-normality seems to be proportionally worse in cases which did not improve.

Crowding in the buccal segments seems to have more of a beneficial effect on reduction than crowding in the labial segment, and the cases still crowded after treatment are the ones in the first group.

Therefore, the favourable occlusal factors appear to be: (1) Establishment of contact between incisors; (2) Original post-normality not too severe; (3) Crowding of mandibular arch, especially the buccal segments.

Table VII.—Original Skeletal Measurements of 49 Treated Cases

		Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
Classification	I	15	3	1
	Mild II	9	6	5
	Severe II	1	2	4
	III	2	1	—
Frankfort–mandibular-plane angle	<24°	6	—	2
	25°–30°	15	10	6
	31°<	6	2	2
Maxillary–mandibular-plane angle	<24°	5	2	3
	25°–30°	14	8	5
	31°<	7	2	2
Gonial angle	<119°	11	2	3
	120°–125°	7	8	5
	126°<	9	2	2
Nasion–sella–gnathion angle	<66°	5	5	2
	67°–71°	17	5	7
	72°<	5	2	1
$\frac{\text{Nasion–gnathion}}{\text{Sella-gnathion}}$ percentage	<97	13	4	4
	98–102	10	5	3
	103<	4	3	3

Soft Tissues.—The soft tissues are shown in *Table VI.*

The variation before and after treatment is more likely to be a change in clinical assessment than an alteration in the soft tissues.

Very little significant difference can be seen between the three groups. Perhaps the third group has a higher proportion of teeth-apart swallows, but the numbers are rather small to prove this. The posture and inter-occlusal clearance certainly seem to be normal in the first group and markedly open and forward in the third group. These may not be causes of the over-bite, but present because of it.

The lip line seems high in most cases.

Thus, very little can be said of the soft tissues except that the worst cases seem to have some relation to a teeth-apart swallowing action.

Skeletal.—*Table VII* shows the original skeletal relationships in these cases.

The majority of the cases where reduction was effected appear to be Skeletal I, while the other groups fall mainly into Skeletal II category. There seems very little difference in the other measurements.

Further lateral skull radiographs taken in the post-retention period were traced and compared with the originals. The results are shown in *Table VIII*, and it seems that some alterations have occurred. Changes of less than 3° were disregarded as these could be due to tracing errors.

In the first group, 4 cases show a decrease in S.Ñ.A.–S.Ñ.B. difference, 8 show an increase in Frankfort–mandibular angle, 6 a difference in maxillary–mandibular angle, and 3 increases in gonial and nasion–sella–gnathion angles. All these changes would seem to be unusual, and certainly favourable to a reduction in overbite. These changes are not so marked in the other groups.

However, swings in the opposite direction are also seen, though not so much in the first group.

The $\frac{\text{nasion–gnathion}}{\text{sella–gnathion}}$ percentage changes do not seem significant.

Therefore the favourable factors in skeletal relations appear to be: (1) Skeletal I base; (2) Tendency for the skeletal relationships to improve.

Having investigated the occlusal, soft-tissue, and skeletal factors, the types of treatment were next investigated.

Table VIII.—Changes in Skeletal Measurements during the Period of Treatment in 49 Cases

Measurement		Overbite Reduced (27)	Overbite Unchanged (12)	Increased (10)
S.Ñ.A.–S.Ñ.B. difference	Decreased	4	—	—
	Unchanged	23	11	10
	Increased	—	1	—
Frankfort–mandibular-plane angle	Increased	8	1	1
	Unchanged	19	9	8
	Decreased	—	2	1
Maxillary–mandibular-plane angle	Increased	6	3	1
	Unchanged	17	9	7
	Decreased	4	—	2
Gonial angle	Increased	3	1	3
	Unchanged	24	7	5
	Decreased	—	3	2
Nasion–sella–gnathion angle	Increased	3	—	—
	Unchanged	23	12	10
	Decreased	1	—	—
$\frac{\text{Nasion–gnathion}}{\text{Sella–gnathion}}$ percentage	Increased	5	2	6
	Unchanged	15	6	4
	Decreased	7	4	—

TREATMENT

The treatment in the 49 cases followed through the post-retention period was investigated under the following headings: (1) Extractions; (2) Appliance therapy; (3) Anchorage; (4) Retention period; (5) Tooth movements achieved.

It was then possible to compare the different types of treatment with regard to the achievement of a reduction in incisor overbite.

1. Extractions (*Table IX*).—The teeth extracted during treatment were noted and compared both in maxillary and mandibular arches in the three groups. Most of the cases had symmetrical extractions, but some were asymmetrical, due either to caries or very badly positioned teeth. Where "½" is shown in the table this indicates an asymmetrical extraction. The numbers become very small when broken up in this way, but certain tendencies emerge, viz.:—

a. In the cases of increased overbite during treatment (Group III) there is a much higher proportion of mandibular extractions, and

b. In these cases the extractions are nearer to the anterior part of the arch.

c. Maxillary extractions do not vary much in the three groups.

The low number of second molars extracted may be due to the fact that this results in a longer line of treatment quite often, and these cases may not have been completed in time for this final survey.

Table IX.—Comparison of Extractions in 49 Treated Cases

		Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
Mandibular	Incisor	1	–	1
	Canine	1	–	–
	1st premolar	4½	2	7
	2nd premolar	2½	1½	1
	1st molar	3	–	–
	2nd molar	–	1	–
Maxillary	Incisor	3	–	–
	Canine	1	1	–
	1st premolar	17	7	9
	2nd premolar	–	–	–
	1st molar	2	1	–
	2nd molar	1	–	–

Table X.—Comparison of Appliance Therapy in 49 Treated Cases

Type of Appliance	Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
Upper removable appliances (28)	13	8	7
Lower removable appliances (4)	2	2	–
Upper fixed appliances (14)	12	–	2
Lower fixed appliances (18)	13	1	4
Andresen appliances (2)	2	–	–
No appliances (7)	2	3	2

2. Appliances (*Table X*).—Appliance therapy was assessed as either removable or fixed. The removable appliances were mainly ones with canine retractors and/or labial bows, and all had had some kind of anterior bite plane to attempt depression with or without proclination of lower incisors.

The fixed appliances were all multiband type with round arch-wires, and had been used for retraction of teeth, proclination and depression of lower incisors, depression of upper incisors, and alinement. A few had been of a Begg type and been used to attempt distal movement of

incisor apices. Also, two Andresen appliances were used.

When split into the three groups, again the numbers were very small. However, it would appear that:—

1. The first group (with reduction of overbite) had proportionally more treatment in the mandibular arch.

2. Some cases had no appliance therapy and yet 2 of these improved in overbite by themselves. (These 2 cases without appliance therapy had been ones with maxillary overcrowding where extractions were carried out but no appliances used.)

The number of cases which had mandibular extractions but no appliances in this arch, although sometimes having upper appliances, was examined and the following results found: (1) Group I, nil; (2) Group II, 1; (3) Group III, 5.

Again, the numbers are very small, but may indicate a tendency for the overbite to be increased if mandibular extractions are carried out in Class II, division 2 cases, but no appliances used.

3. Anchorage (*Table XI*).—It was noted whether intra- or inter-maxillary traction or extra-oral traction or a combination of these were used. The results do not appear to be significant in the three groups, except that more inter-maxillary was used in the first group. Intra-maxillary was not used in the mandibular arch because the danger of collapse or over-retroclination of labial segment was realized.

Very few cases had extra-oral traction compared with those now under treatment.

4. Retention Period (*Table XII*).—This was checked in each case and found to vary from none at all to three years.

The retention was by removable appliances, often both upper and lower. Where no lower appliance was used, the upper appliance had a bite-plane anteriorly to maintain the lower incisors. In two cases monoblocs were used.

Table XI.—Comparison of Anchorage in 49 Cases

Type of Anchorage	Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
Intra-maxillary only in maxillary arch (20)	10	5	5
Intra-maxillary only in mandibular arch (0)	—	–	–
Inter-maxillary (19)	14	1	4
Extra-oral (reinforcing intra- and inter-) (3)	3	–	–

The cases had all been out of retention at least six months when seen.

The time of retention includes full-time and half-time wearing.

On the whole, it appears that long periods of retention may be beneficial to reduction in overbite. The one case of three years' retention where no alteration in overbite was achieved was found to be an extreme case.

Table XII.—Comparison of Retention Periods in 49 Cases

Retention Period	Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
None	2	3	2
6 months	1	4	4
12 months	20	4	3
18 months	2	–	–
2 years	2	–	1
3 years	—	1	–

5. Tooth Movements Achieved (*Table XIII*).—Actual tooth movements achieved and maintained into the post-retention period were examined clinically and on lateral skull

radiographs. Owing to difficulties of finding fixed points on lateral skull radiographs some of the movements, e.g., depression and apical movement, were extremely hard to confirm.

The angulations of maxillary incisors were checked first. In the first group, 4 cases had maintained proclination, but these may have been due to distal movement of apices rather than labial movement of crowns. In the other two groups quite a large proportion had a sustained slight proclination.

The mandibular incisors in the first group show a high percentage of sustained proclination, although the other two groups also show some proclination.

Quite large percentages of all the groups show a further retroclination of both upper and lower incisors.

Almost half of the maxillary incisors in the first group remained unchanged.

There appeared to be more relative depression of lower incisors in the first group.

Depression of upper incisors seemed to appear clinically, but could not be proved in many cases on lateral skull radiographs.

Table XIII.—Comparison of Tooth Movements in 49 Cases

Tooth Movement	Overbite Reduced (27)	Overbite Unchanged (12)	Overbite Increased (10)
Proclination of maxillary incisors	4	4	3
Proclination of mandibular incisors	20	4	4
Retroclination of maxillary incisors	12	5	6
Retroclination of mandibular incisors	6	6	7
Maxillary incisors unchanged	1	1	1
Mandibular incisors unchanged	1	1	–
Distal movement of maxillary incisor apices	4	–	1
Depression of mandibular incisors	23	2	1
Depression of maxillary incisors	1	–	–

DISCUSSION

From all the factors investigated it was seen that the following may be favourable in reduction of overbite.

1. At the Time of Diagnosis.—

a. Skeletal Class I (or mild II).—No other skeletal factor appeared to be favourable at this stage.

b. Occlusal.—Crowding as opposed to spacing; No excessive post-normality of buccal occlusion; Overbite not severe to start with.

c. Soft Tissues.—Normal; Habits and tongue-thrusting seemed beneficial.

2. Treatment.—

a. Extractions.—These should be avoided in the anterior part of the mandibular buccal segments.

b. Appliances.—Appliance therapy should be used to procline and depress lower incisors and must be used to close lower spacing if extractions are carried out.

c. Retention.—Long periods of retention seem advisable, especially when growth is still proceeding.

d. Tooth Movements.—Proclination and depression of lower incisors with attempts to establish incisal contact seems necessary for sustained reduction.

3. During Period of Treatment.—Some cases improved, therefore it is possible that slight skeletal alterations which may be favourable might occur. These have not been proved and cannot be predicted, but may be related to alterations in occlusion or in general growth

and development. Long periods of retention after treatment may allow the effects of these factors to be seen.

4. Factors at the End of Treatment.—

1. Established occlusion. Incisal contact and occlusion in muscle balance seem essential.

2. Normal soft tissues will maintain a balanced occlusion.

3. Growth may not be complete and further changes may be expected.

The case of P. C. was compared with these findings and it was seen that in his case he had very few favourable factors to start with, except a mild Skeletal II base and normal soft tissues.

However, during treatment, mandibular spaces were closed, the incisors proclined and depressed, and an incisal contact achieved.

He showed slight skeletal changes and post-treatment alterations in occlusion which were allowed to settle favourably during the long retention period.

CONCLUSION

This paper has been an attempt to show some factors concerned with the reduction of excessive incisor overbite in Class II, division 2 cases.

The number of cases has proved to be too small to show any significant facts.

The methods of recording soft tissues is believed to be unsatisfactory as they cannot be checked in the original state.

The lateral skull radiographs have some inaccuracies which prevent measurements to anything less than $\pm 2^\circ$ and slight variations render linear measurements impossible. Also the lack of fixed points makes the assessment of tooth movement difficult.

Even the models, divorced from their surroundings, cannot always be compared completely with the final result.

However, certain trends seem to emerge which may be useful in further studies in this field and it is obvious that many other factors are present as yet unknown, or at least unrecorded, and difficult to measure.

Acknowledgements.—I should like to express my thanks to the Consultants and Members of Staff at the Royal Dental Hospital and the Hospital for Sick Children for their permission to examine their cases and for helpful criticism. I should also like to thank the Photographic Department at the Royal Dental Hospital for the photographs.

DISCUSSION

The Chairman thanked Miss Ridley and said that this type of analysis of treated cases was of vital importance and he hoped that other members would follow her example in the future. It was essentially a long-term research and meant not only meticulous notetaking and recording and collecting material very carefully from the very beginning, but also remaining long enough in the same place, not only to see the treatment through but also to see the cases when they were out of retention.

He then called on Mr. Hovell to open the discussion.

Mr. J. H. Hovell said that he was very pleased to be able to open the discussion on Miss Ridley's paper, because it commenced to answer criticism one heard from overseas—and he included Ireland in that category—regarding English research work. It had been suggested that they said a lot of things without ever having shown them.

At the Royal Dental Hospital they were now building up a large stock of records, both lateral skulls and models, of treated cases, which were a very valuable source of material for analytical research work of that nature, of which there was no doubt too little was being done at the moment in this country. It was obvious, when one saw the paper, why there was too little. It was no job for anyone who was afraid of hard work.

As well as demonstrating little changes during treatment and retention in those cases, the measurements presented also demonstrated quite incidentally the overall stability of the facial skeletal pattern during the growth period, the comparatively small changes which were in fact taking place, and how even those small changes could affect the issue.

Miss Ridley's statement that the Class II, division 2 malocclusion or classification of Angle comprised many different types of cases was undoubtedly true. Those different types had different aetiologies in all probability. For example, that of the same dental malocclusion on a Class II and on a Class III dental base.

He did not like Miss Ridley's use of the term "lip posture". He preferred to think of soft-tissue patterning of the lips as comprising three features: first, morphological features; secondly, patterns of activity during swallowing; and thirdly, habit activities.

Morphological features, into which fell competent and incompetent lips, were not dependent upon musculature activity, and could not therefore readily be called postural. Habit activities, however, were produced by active musculature and were postural. A distinction ought to be made there, because it was not just a matter of nomenclature; it was a matter of what was happening

in those cases. This is unlike the term "incompetent lips", to which some members of the Society objected and to which there was no reasonable alternative. Since by definition all orthodontists should be aware of what that term meant when used by fellow orthodontists, its use was justifiable, and he could think of no better term to replace it.

Certain findings in the paper caused him some surprise.

As many as 10 cases had incomplete overbite due to tongue thrust; he would not have expected so high a percentage of tongue thrust as that. Moreover, none of the tongue thrusts had a lisp, apparently. That again seemed contradictory. It would seem to him that a tongue thrust in a Class II, division 2 malocclusion must be an innate activity and not a habit activity, and yet, in his experience, it was very rare for innate tongue thrusts to have no speech defect. Perhaps Miss Ridley could shed more light on that?

He would like to see different types of cases analysed —that was a job for someone else—to see whether the same figures came out.

Another surprising finding to him was the high percentage of increased intra-occlusal clearances and distal paths of closure. Was it possible that a number of those cases were not true distal paths of closure, but were habit activities of a downward and forward resting posture with incisal contact? Those were very common in Class II, division 2 cases, and true distal paths of closure with increased intra-occlusal clearance very rare. It was very much dependent on clinical estimation, and it was very difficult, as Miss Ridley said, to assess and make foolproof or unassailable statements on it. The fact that the number of retrusive paths of closure, increased intra-occlusal clearances, and incompetent lips habitually together all increased at the end of treatment would seem to bear out that point of view, that they might be habit activities, as everyone knew that those habit activities were frequently associated with habit sealing of incompetent lips and increased markedly during that age period.

Could Miss Ridley explain the better prognosis for reduction of overbite in cases with crowding of the lower buccal segments? Did she think it was because, in those cases, loss of continuity in the lower buccal segments early on during the development of the occlusion had permitted the lower labial segment to tilt lingually, and that that could therefore be proclined slightly during treatment if it was buttressed forward by buccal segments in good alinement? Miss Ridley had mentioned the effect of closing spaces and bringing the upper space up against the labial segment. The question of forward buttressing was one on which some more information was needed. He was sure it occurred, as could be seen in cases of asymmetrical loss of buccal segment support. He felt that, in adulthood, the labial segment frequently tended to crumple up in those cases and drop back to its normal position in soft-tissue balance, thus producing a late relapse—the sort of case the periodontist was more likely to see than anyone else. In other words, one was wiser not to rely in treatment planning upon buccal support for labial segments. He hoped that Miss Ridley would be able to follow up those cases for a sufficient period of time to check upon that. Has Miss Ridley related the cases which improved to the possibility that the incisor position originally produced by the soft-tissue patterning would have placed the lower incisal edge in unstable relationship to the palatal surface of the upper incisor? In other words, treatment had just enabled the lower incisors in some cases to slip labially from that unstable position instead of palatally. He referred to Backlund's work in that respect.

Mr. H. L. Leech said that he was very interested in the Class II, division 2 cases. He had been using the Begg multi-band appliance for a good many years. In those cases where he had attempted to reduce the overbite by moving the apices of the upper incisors palatally, he had been disappointed. He was coming to the conclusion that this type of treatment was doomed to relapse. He wanted to know if Miss Ridley had had the same experience. He found that they had to be retained for a very long time and he was not sure that a removable appliance was sufficient. He thought that the permanent reduction of incisor overbite was very nearly impossible in those cases. He found that in some cases the relapse did not necessarily occur soon after the removal of retention, but, in one case particularly, which he was hoping to show next year, a little relapse occurred after one year but a great deal during the next three years, of the incisor overbite. He made a plea that Miss Ridley should follow up cases for some years afterwards to see if that occurred.

He was interested in the increase in the angle between the Frankfort plane and the mandibular plane during treatment and wondered if Miss Ridley related that in any way to the inter-occlusal clearance before and after treatment.

Mr. E. K. Breakspear said that during the last two or three years he had formed an empirical policy of trying to separate out what might be called the natural and artificial factors in such a case. For example, if there was early loss of teeth in the lower arch, he regarded that as something additional. He felt that, in those cases, he could restore the lower arch to a certain extent, thereby returning it to the condition in which it would have been originally, had there been no extraction. Beyond that point, he felt very hesitant to go. Would Miss Ridley agree that that was a sound type of approach in the initial stages?

His second question was, Had she noticed any change due to psychological causes? He noticed 77 per cent of cases had lip contraction and he felt that, in some cases, that was affected by the child's outlook. In one or two cases he had in mind it seemed to happen that the child grew older and got a better outlook on life—he might not—but if he did, then there was a certain relaxation of general tension. In those cases, he had found that he had been able to get some improvement in the overbite which, apart from psychological change, he would not have expected. He would like Miss Ridley's comments on that.

Mr. G. C. Dickson had two small points to raise.

Miss Ridley had said that she did not think it was possible to measure angles accurately to nearer than 3°. He understood that 3° was the change in the ANB angle that she regarded as significant, and felt that the degree of change which could be regarded as significant depended very much on the particular angle that was being measured. He would have thought that the angle ANB could be measured accurately to 1° on any good lateral skull film and that a change of 2°, which was shown in the first case she had recorded, was in fact significant. It was 2° in 7° which, if his arithmetic was correct, worked out at something between 25 and 30 per cent change.

Miss Ridley had said that she could not suggest any method of knowing in advance whether or not favourable

growth change could be predicted. He wanted to point out the work of Ricketts in that field and suggested that if one could get one's cases a year or two before starting active treatment, some idea of the growth trend could be made—if one was able to get a lateral skull 2 years before treatment commenced so that the change could be seen on a subsequent film; in other words, one was treating on a dynamic and not a static picture.

Mr. W. A. Nicol said that out of all the great variety of features that were difficult to assess, one feature apparently was common to all Class II, division 2 cases, and that was the high lip line in relation to the central incisor teeth. That was particularly gratifying to him. When it came to treating Class II, division 2 cases and assessing the results of treatment, Miss Ridley said that she thought the upper incisors were sometimes depressed but that that was impossible to measure or to assess on analysis. He suggested that it might be possible to measure some difference in the relation of the incisors after treatment to the lip line, and, as that was a constant feature of Class II, division 2, it might be of some value.

Mr. C. D. Parker: Did Miss Ridley think that the behaviour of the maxillary–mandibular-plane angle during treatment had any influence upon the re-establishment of the deep overbite? In other words, were those cases in which the maxillary–mandibular-plane angle opened during treatment more likely to relapse?

Mr. J. K. Wilkie said that he had the impression that in some of the Class II, division 2 cases, a patient would swallow with the incisor teeth in contact and the cheek teeth apart. Had Miss Ridley noted that?

Mr. P. J. Holloway asked Miss Ridley if she made any observations on the condition of the periodontal tissues around the anterior teeth in those cases?

Miss Ridley, in reply, first of all thanked the President for his remarks. She then thanked Mr. Hovell for his remarks and said that she was very pleased that he had given up his time to open the discussion on her paper.

Mr. Hovell had, she noticed, disapproved of the term, or her misuse of the term, "lip posture". Of course, he was quite right, as usual! She was attempting to express competence and habitual posture at the same time, as that was more convenient from the point of view of clinical assessment.

On the question of tongue thrusts, those mentioned were not severe and perhaps should have been called "forward position of the tongue during swallowing". In most of the cases, there was no anterior open bite present. She was not an expert on speech at all, but she would have thought that a lisp was more often associated with an anterior open bite.

On the question of whether the thrusts were endogenous or not, she was not very good at determining this at the first assessment. However, if they disappeared, she put them down as "habitual" but if they persisted she called them "endogenous"!

With regard to the point about intra-occlusal clearance and mandibular posture, she thought the answer was that the records were incomplete on these aspects and in the original assessments made several years ago they may have confused a forward posture with a distal path of closure. That was a misrepresentation of the term and would explain the unexpected results. She would not attach too much importance to any of those findings because she was not very certain of them herself.

On the question of crowded buccal segments, the main point she wanted to stress was not to leave them crowded but to attempt to close the spacing. She was very interested in what Mr. Hovell said about cases relapsing later on in life, even if one had managed to hold the labial segments forward by closing the buccal spacing. She did not think any work had been done on following through cases into the adult state. One or two of her patients were around 21 years and 22 years, but she thought that the relapse Mr. Hovell talked about would occur nearer to 30 years of age, with a general deterioration of the periodontal condition, and often following on some loss of teeth due to caries.

She thought that the improvement in the cases was mainly due to a better incisal contact, the lower incisors going incisally rather than palatally. She thought it was important to try to achieve good contact with maxillary incisors, but felt that the movement should be of the mandibular incisors and not the maxillary. If possible, leave the maxillary incisors alone, because they were in muscle balance, and if an attempt were made to move them, they would probably relapse back again. Instead, an attempt should be made to do most of the alterations in the mandibular teeth.

She thanked Mr. Leech for his remarks; it was Mr. Leech who had taught her how to use Begg arches and he knew more about them than she did. She had used a Begg arch on P. C. and the incisors had appeared to relapse back again. The final result depended on the severity of the case, which was probably the main point, and there were some cases in which, whatever treatment was used, a good incisal relationship would not be obtained.

With regard to the relationship between alteration in Frankfort–mandibular-plane angle and intra-occlusal clearance, there again she wished that she could have recorded the original intra-occlusal clearance. The only note she had was that it was slightly increased before treatment and was normal after treatment and that sort of recording was not very reliable. She wished she had had better records before starting treatment because she could not really relate a difference to the increase of the Frankfort–mandibular-plane angle.

Regarding Mr. Breakspear's question, his appeared a very sound approach to her. The point about correcting the effects of early loss was very good; and then going on to other factors later, as they arose.

She was very interested in what he had said about the psychological aspect. She had not gone into that because she really did not know anything about it, and one could not investigate all the different aspects. But she personally felt—although she had no scientific backing for it—that many of the Class II, division 2 cases had a peculiar psychological make-up. They tended to be rather nervous and it was very interesting that Mr. Breakspear should have noticed this also.

She thanked Mr. Tulley for his remarks, but did not really think that he had asked her a question which called for an answer.

In reply to Mr. Dickson, she said that *she* could not measure to that degree of accuracy. She had taken some lateral skull radiographs herself and she knew how much the ear-plug moved, and also that the head could move as it was not held rigidly. Also some of these radiographs were taken on different machines. She had traced some of them again and found a slight variation. Some people might be able to achieve greater accuracy, but she had thought that she ought to say that for her, personally, $\pm 2°$ was really as accurate as she could get. Mr. Dickson had mentioned the percentage of change; she had not

really meant that a difference of 2° was not statistically significant, but that due to her error of ±2° an alteration of more than this was needed to show a definite change.

The idea of Ricketts, i.e., of taking lateral skulls for a year or two, before starting treatment was a good one and it would be very helpful if that could be done in all cases.

She thanked Mr. Nicol for his remarks which, in the case of measuring the lip line, would have been useful. However, the distance would have to measured exactly before treatment, and she had not done that. She just assessed whether it was high or low. To be able to tell whether they had actually been depressed, it would have to be measured exactly.

The only note that she had in reply to Mr. Parker was "No, they didn't", and she hoped that answered his question!

Mr. Wilkie had mentioned swallowing with the incisor teeth together but cheek teeth apart. She thought that this type would be included in what she was calling the "teeth-apart swallow".

In reply to Mr. Holloway, she said that there were 36 cases of very deep overbite and all those certainly were associated with some stripping of the gingivæ. That was the only note she had made about gingivæ.

Physical Properties and Manipulation of Rubber Impression Materials

Much of the controversy regarding the manipulation and properties of these materials has been resolved.

Composition.—There are two types of rubber elastometers, both polymerizing into a long chain-coiled molecule which is very elastic. One type is a polysulphide rubber and the other has polydimethyl siloxane as its chief ingredient. An example of the former is thiokol and has the mercapton base; other ingredients are fillers and carriers. The shelf-life is excellent, and most types are now supplied with rubber of varying viscosities; a thin material for injecting into cavities and a heavy paste for the tray. Details of the silicone base materials are not so well known, and certain products present the problem of hydrogen-gas evolution during curing, resulting in a pitting of the stone model. Various means nave been used to overcome this, e.g., the use of hydrogen acceptors, chromium oxide, and aldehydes, or an alteration in the method of polymerization. Merits of the silicones are improved colour, odour, and cleanliness in handling, but the shelf-life is inferior to the polysulphides. Equally satisfactory clinical results may be obtained with either material.

Setting Time.—There must be sufficient working time to allow for mixing, injecting, and seating the tray. Polymerization should then take place rapidly enough to prevent any distortion while the tray is in position and to allow early removal. Generally, the silicones set more rapidly than the polysulphides. Temperature and humidity will influence setting time, especially for polysulphides; the higher the readings the more rapid the set. Mixing is continued until the colour is uniform, since the diffusion of the catalyst is of the same order as for the colouring agents. The stiffness of the material at the time the tray is seated will have an effect on the accuracy of the impression. Adequate time for curing is essential before the material is removed from the mouth; the minimum time is 8 minutes, allowing 10 minutes in all from the beginning of the mixing.

Bulk of Material.—The smallest amount of material necessary to obtain an impression will reduce the risk of trapping bubbles and of polymerization shrinkage. The attainment of this aim is helped by careful selection of tray or band. The tray must be rigid and held so during setting.

Dimensional Stability.—This is a problem with all impression materials. Polymerization continues after removal of the impression from the mouth, and the material contracts. Release of internal stress is always taking place and probably influences stability. Collapse of subsurface bubbles and volatilization of some of the ingredients also contribute to distortion. Storage of an impression beyond one or two hours invites failure, and immediate pouring of the die is desirable.

Electroplating.—The rubber materials may be readily electroplated. Silver gives the best results with polysulphides and copper with the silicones, although plating of the latter is not recommended with techniques presently available.—PHILLIPS, R. W. (1959), *J. Amer. dent. Ass.*, **59**, 3.

G. E. B. MOORE